STILL WATERS

HOUSE OF COMMONS
CANADA

STILL WATERS

Report of the
Sub-committee on Acid Rain
of the Standing Committee on
Fisheries and Forestry

Compliments of:
Tom McMillan M.P.
Hillsborough

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First Session of the
Thirty-second Parliament 1980-1981

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RECOMMENDATIONS

National Energy Program

1 The Sub-committee recommends that grants from the National Energy Program's Utility Off-Oil Fund for conversion of oil-fired electricity plants to coal be made conditional upon the installation of the best available emission control technology for oxides of sulphur and nitrogen. (p. 38)

Coal-Fired Power Plants

2 The Sub-committee recommends that all conversions of oil-fired electricity plants to coal in Canada, whether or not such conversions are financed in whole or in part by government funds, be carried out utilizing the best available emission control technology for oxides of sulphur and nitrogen. (p. 38)

Nova Scotia Power Corporation

3 The Sub-committee recommends that the Lingan Generating Station operated by the Nova Scotia Power Corporation at Cape Breton be compelled to utilize the best available emission control technology for oxides of sulphur and nitrogen. This recommendation applies to generating units presently in operation and to those units planned or under construction. (p. 39)

Coal-Fired Power Plants

4 The Sub-committee recommends that all new coal-fired electricity plants planned or under construction in Canada be compelled to utilize the best available emission control technology for oxides of sulphur and nitrogen. (p. 40)

Ontario Hydro

5 The Sub-committee recommends that the Federal Government urge the Ontario Ministry of the Environment to compel Ontario Hydro to utilize the best available technology to control emissions of sulphur and nitrogen oxides at all existing and new coal-fired electrical generating stations in that province. (p. 40)

INCO Limited

6 The Sub-committee recommends that the INCO Limited smelter at Copper Cliff, Ontario be compelled to reduce its sulphur dioxide emissions to 750 tonnes per day and that this level be attained within five years. (p. 44)

7 The Sub-committee recommends that the INCO Limited smelter at Thompson, Manitoba be compelled to reduce its sulphur dioxide emissions to 220 tonnes per day and that this level be attained within five years. (p. 45)

Falconbridge Nickel Mines Limited

8 The Sub-committee recommends that the Falconbridge Nickel Mines Limited smelter at Sudbury, Ontario be compelled to reduce its sulphur dioxide emissions to 210 tonnes per day and that this level be attained within five years. (p. 45)

Noranda Mines Limited

9 The Sub-committee recommends that the Noranda Mines Limited (Mines Gaspé) smelter at Murdochville, Quebec be compelled to reduce its sulphur dioxide emissions to 115 tonnes per day and that this level be attained within five years. (p. 45)

Noranda Mines Limited

Hudson Bay Mining and Smelting

10 The Sub-committee recommends that the Federal Government, in full consultation with concerned Provincial Governments and industry officials, convene a Task Force to study appropriate technologies and economic initiatives to implement an 80 per cent sulphur containment objective at the non-ferrous smelters operated by Noranda Mines Limited (Horne Division) at Noranda, Quebec and by Hudson Bay Mining and Smelting Company Limited at Flin

Flon, Manitoba. The Task Force should be convened immediately and should report within a six-month period. (p. 46)

Motor Vehicles

11 The Sub-committee recommends that NO_x emission control standards for new motor vehicles sold in Canada be made at least as stringent as those enforced in the United States by the Environmental Protection Agency as of June 1981. (p. 47)

Motor Vehicle Safety Act

12 The Sub-committee recommends that legislative authority to regulate motor vehicle emissions through standards applicable to manufacturers and distributors be transferred from the **Motor Vehicle Safety Act** to the **Clean Air Act** and hence from the Ministry of Transport to the Department of Environment which already has significant responsibilities in the area of air pollution. (p. 47)

Forests

13 The Sub-committee recommends that Environment Canada continue an intensive research program into the effects that acid rain is having on Canadian forests. The Sub-committee further recommends that the Federal Government conduct a thorough review of the structure and funding of the Canadian Forestry Service to determine if there is a need for increases in funding and/or person-years to effectively deal with the research requirements necessitated by the acid rain problem. (p. 52)

Agriculture

14 The Sub-committee recommends that Agriculture Canada develop a comprehensive research program to study the effects of acid rain on crops and soils in Canada. This research program should include studies of the effects of acid rain precursors and ozone on crops and particular attention should be given to the effects that current fertilization practices are having on soils to render them more sensitive to cumulative acid loadings. (p. 53)

Liming

15 The Sub-committee recommends that liming, as a mitigative strategy against acid rain damage, be considered by governments only for selected waterbodies to raise the pH of the water to restore and/or protect desirable fish populations. The Sub-committee emphasizes that liming must not be regarded as a substitute for the control of acid rain-causing emissions at source. (p. 59)

Drinking Water

16 The Sub-committee recommends that the federal Department of Health and Welfare and the Department of Environment, in cooperation with provincial authorities, accord high priority to a research program to identify levels and species of toxic metals in potable water supplies in Canada with special emphasis being given to those areas under greatest impact from acid precipitation. (p. 64)

Mercury in Fish

17 The Sub-committee recommends that the Federal Government examine its research program to ensure that adequate funding is being provided for research to determine the relationship between acidic precipitation and mercury contamination of fish in sensitive lakes and streams. We further recommend that suitable public health monitoring programs be initiated to determine the degree of risk faced by those populations whose diet contains large amounts of fish from sensitive areas. (p. 64)

Monitoring

18 The Sub-committee recommends that Environment Canada, in consultation with appropriate provincial ministries, carry out a comprehensive review of all aspects of monitoring acidic precipitation in Canada. Of particular importance is the need for standardized methodology to permit ready comparison of results obtained by the various monitoring systems operating in Canada. (p. 68)

19 The Sub-committee recommends that Environment Canada accelerate its efforts to make Canadian and United States precipitation chemistry monitoring systems compatible in terms of providing data of acceptable comparability. (p. 68)

20 The Sub-committee recommends that the Federal Government provide appropriate funding for an effective research program to develop an accurate and reliable method for the monitoring of dry deposition. (p. 69)

Alberta

21 The Sub-committee recommends that the Government of Alberta accord maximum priority to the control of acid rain-causing pollutants from industries in the province. The Sub-committee recommends that the Provincial Government adopt as its guiding policy a goal of zero increase in acid rain-causing emissions over present levels up to the year 2000, and an annual decrease by a prescribed amount each year thereafter. (p. 75)

Clean Air Act

22 The Sub-committee recommends that the Federal Government develop comprehensive National Emission Guidelines (compulsory once adopted by a province) to cover all facilities, whether existing, converted, or new, which are sources of sulphur dioxide and nitrogen oxides, and hence of acid rain. (p. 81)

23 The Sub-committee recommends that the **Clean Air Act** be amended to enable the Federal Government to develop National Emission Standards to cover sources of sulphur dioxide and nitrogen oxides resulting in interprovincial air pollution and acid rain. (p. 83)

24 The Sub-committee recommends that where appropriate the Federal Government invoke ss. 20 and 21 of the **Clean Air Act** which allow the Minister of the Environment to recommend Specific Emission Standards to the Cabinet which would be applicable to works, undertakings or businesses in a particular industry or region within a province which has, by federal-provincial agreement, accepted National Ambient Air Quality Objectives. (p. 83)

Notice and Comment

25 The Sub-committee recommends that an appropriate uniform notice and comment procedure be provided for in the **Clean Air Act** and that it be applicable at the earliest possible moment in the development of National Ambient Air Quality Objectives, National Emission Standards, Specific Emission Standards and National Emission Guidelines. (p. 84)

Environmental Protection Legislation

26 The Sub-committee recommends that the following elements be included in environmental protection legislation to effectively reduce pollution in general, and particularly acid rain-causing air pollution:
1) The imposition of penalties high enough to ensure there is no benefit from saved costs of compliance in cases of non-compliance.
2) The creation of a tribunal which would have exclusive jurisdiction over environmental law prosecutions.
3) The creation of class action suits, private prosecutions and citizen civil suits.
4) The provision of a funding mechanism for class action suits which would otherwise not be instituted due to inadequate financial resources on the part of the initiators. (p. 86)

27 Pending consideration and implementation of the reforms advocated in the previous recommendation, the Sub-committee recommends that effective steps be taken to apply existing environmental protection legislation, particularly as it relates to acid rain-causing air emissions. Among the steps that should be immediately taken by governments and the courts are:

1) The provision of additional legal and technical staff to environment departments.
2) The acceleration of court proceedings.
3) The harmonization of federal and provincial enforcement of environmental protection legislation. (p. 86)

Regulatory Alternatives

28 The Sub-committee recommends that governments consider innovative acid rain control regulatory alternatives which have been tried with some success in other countries — for example, the Bubble Concept, Emission Offsets and Credits, etc. The Sub-committee further recommends that such regulatory alternatives should not be adopted where their effect would be to allow an overall increase in air emissions above the desired levels. (p. 87)

Access to Information

29 The Sub-committee recommends that appropriate legislative provision be made to permit public access to all records and data pertaining to the discharge of contaminants into the Canadian environment. (p. 88)

Canada- U.S.A. Agreement

30 The Sub-committee recommends that Canada and the United States reach an agreement on the necessary legislation and mechanisms to substantially reduce transboundary air pollution, particularly as it relates to acid rain, by the end of 1982. (p. 92)

U.S. Emissions

31 The Sub-committee recommends that governments, public interest groups, and individual Canadians in general explore and utilize all possible political, legal, administrative and media channels to ensure that acid rain-causing emissions originating in the United States are substantially reduced and that a Canada-U.S. agreement on the long-range transportation of air pollutants is signed by the end of 1982. (p. 94)

International Parliamentary Associations

32 The Sub-committee recommends that the acid rain problem and its transboundary implications be publicized and discussed at appropriate meetings of International Parliamentary Associations attended by Canadian legislators. Of particular importance are the annual meetings of the Canada-United States Interparliamentary Group. (p. 95)

Public Awareness

33 The Sub-committee recommends that Environment Canada, in cooperation with appropriate provincial authorities, continue and expand its public awareness and information program on acid rain to alert and educate the Canadian public, particularly in those provinces and regions of Canada where the issue has not yet attained sufficient prominence. (p. 100)

34 The Sub-committee recommends that a major public awareness and information program is necessary to generate public concern in the United States about the acid rain problem and the threat it poses to the Canadian and American environments. The present program should be continued and expanded and consideration should be given to inviting influential American media representatives to Canada so they can be apprised of the transboundary effects of U.S.-sourced air pollution. (p. 100)

Accelerated Capital Cost Allowance

35 The Sub-committee recommends that Accelerated Capital Cost Allowances continue to be granted for air pollution control devices and that these allowances be extended to new plants. (p. 117)

Polluter-Pay Principle

36 The Sub-committee recommends that the polluter-pay principle apply to the cost of installing abatement equipment in any future production facilities whose operations have the potential to emit oxides of sulphur or nitrogen. (p. 117)

Sulphur By-Products

37 The Sub-committee recommends that the Federal Government, in co-operation with the Provincial Governments and the private sector, convene a Task Force on sulphur by-product utilization with the aim of developing a national marketing strategy for sulphur and sulphur products. Such a marketing strategy would involve finding new uses for sulphur products and may include the formation of a marketing board for sulphur and sulphur products. (p. 118)

Canadian Phosphate Deposits

38 The Sub-committee recommends that Canadian phosphate deposits be developed as a market for the sulphuric acid produced by control of sulphur dioxide in non-ferrous smelters. (p. 119)

PREFACE

The Sub-committee on Acid Rain was first appointed on July 18, 1980 by the Standing Committee on Fisheries and Forestry. The Sub-committee consists of nine Members of Parliament representing all three federal parties in the House of Commons.

The Sub-committee's Order of Reference called for a consideration of Environment Votes relating to the Main Estimates for the fiscal year ending March 31, 1981, and "specifically those related to the costs and effectiveness of finding solutions to the acid rain problem". The Sub-committee was scheduled to report to the Standing Committee by November 10, 1980.

Once the Sub-committee commenced its investigation of the acid rain issue, however, it became obvious that the original mandate was too narrowly specific and, also, that the November 10 deadline for reporting was unrealistic. On December 11, 1980, the Sub-committee was re-appointed by the Standing Committee upon the instructions of the House of Commons on December 5, 1980; the Sub-committee thus received a new Order of Reference to continue its investigations until March 1, 1981 and the field of study was broadened to include all aspects of acid rain.

The Sub-committee presented its First Report to the Standing Committee on February 12, 1981 and recommended that the date of submission of its Final Report be extended to June 30, 1981. This recommendation was presented to the House of Commons and accepted. On June 16, 1981, the Sub-committee received a further extension until October 15, 1981 for printing and distribution of its report.

Over the period of its investigation, the Sub-committee received evidence at four public hearings, in Toronto (October 2 and 3, 1980), Montreal (January 26 and 27, 1981), Calgary (February 16, 1981), and Halifax (April 13, 1981). In addition, we have received detailed briefings and extensive documentation on the acid rain phenomenon. To obtain a broadened perspective on this important global problem, the Sub-committee travelled to Washington, D.C., London, United Kingdom, and Stockholm, Sweden for extensive briefings and discussions.

The Sub-committee received invitations from a number of Canadian corporations to visit their installations and to discuss with them a myriad of issues pertaining to the acid rain problem, particularly as it relates to the extraction and processing of Canada's natural resources. Although we were unable to accept every invitation, the Sub-committee visited INCO Limited and Falconbridge Nickel Mines Limited in the Sudbury, Ontario region; Suncor Incorporated and Syncrude Canada Limited in Fort McMurray, Alberta; Brunswick Mining and Smelting Corporation Limited in Belledune, New Brunswick; and Mines Noranda Limitée, Noranda, Québec. The Sub-committee gratefully acknowledges the courtesy and generosity of these companies, and also those whose facilities we were unable to visit.

Over the period of its tenure, the Sub-committee has received the assistance and cooperation of many groups and individuals from all parts of Canada and from other countries. We extend our sincere thanks to all of these and refer the reader to the appropriate appendices to the report for the names of those who contributed to our investigation. We are particularly grateful to those officials of the Provincial Governments who provided documentation and evidence; some of these provincial officials travelled considerable distances to appear at our public hearings.

We thank the Department of External Affairs for assisting the Sub-committee during its international travels. We are similarly grateful to the Departments of Transport and National Defence for providing government aircraft for parts of the Sub-committee's travel, in Canada and abroad. The Department of Environment has assisted the Sub-committee in numerous ways throughout its tenure and for this we are very grateful.

The Sub-committee thanks the Research Branch of the Library of Parliament for providing research assistance, particularly in the latter stages of our investigation and in the writing of this report; also, we thank the Reference Branch of the Library for continuing assistance in supplying necessary reference materials. Other services of the House of Commons, often taken for granted but absolutely essential to committee work, are acknowledged with gratitude.

The Sub-committee has noted that many members of the media in Canada have developed an insightful and growing appreciation of the acid rain problem and the threat that this pollutant holds for the North American environment. We wish to express our gratitude to these journalists, in all parts of Canada, and we urge them to continue and expand their coverage of the acid rain issue.

From the outset, the nine members of the Sub-committee adopted a non-partisan approach to the acid rain issue. There was an immediate and firm consensus among all members that the seriousness of the problem and the need for a solution transcended all political affiliations.

There were times when the Sub-committee was apprehensive that we would be overwhelmed by the complexities and magnitude of the acid rain problem and by the sheer volume of the documentation and evidence to be reviewed. Nevertheless, the Sub-committee was able to meet the demands required of it. We present this report in the spirit of the words of John Stuart Mill:

> *Men and governments must act to the best of their ability. There is no such thing as absolute certainty but there is assurance sufficient for the purposes of human life.*

Ronald Irwin, M.P.
Chairman

INTRODUCTION

Canada is facing the greatest environmental threat in the 114 years of our existence as a nation. The cleansing rains and pristine snows that once fell on this land have become dangerously acidic and destructive.

Acid rain, a term unknown a decade ago, has become the most pervasive and most feared environmental pollutant in North America. In a speech in Boston, Massachusetts in March of this year, the Minister of Environment Canada, the Honourable John Roberts, told his American audience that:

> *Acid rain is the most serious air pollution problem facing our two countries today... The situation is already intolerable. Unless we take swift action, it's going to get worse instead of better in the years ahead.*

Acidic precipitation, which includes rain, snow, sleet and hail, is usually defined as having an acidity below pH 5.6.(1) Acid rain (a technically incorrect but accepted synonym for acidic precipitation) is primarily the result of emissions of sulphur oxides (SO_x) and nitrogen oxides (NO_x) which are transformed into sulphuric acid (H_2SO_4) and nitric acid (HNO_3), respectively as they are transported by the atmosphere over distances of hundreds to thousands of kilometers.

The process by which acids are deposited in rain or snow is called "wet deposition". A second process, known as "dry deposition", is also included under the definition of acid rain. In this process, particles such as fly ash, sulphates and nitrates, and gases such as sulphur dioxide and nitric oxide are deposited on, or adsorbed onto, surfaces. These dry particles or gases can be converted into acids after deposition when they contact water.

Extensive research over many years indicates that much of eastern Canada is sensitive to acid rain because of a lack of natural buffering or neutralizing capacity in the rocks and soil. Coincident with this fact is the observation that hundreds of lakes in Ontario are devoid of fish because of acidification. Scientific evidence suggests that if acid rain is not controlled, thousands of lakes in Ontario will be destroyed by the year 2000. Evidence presented by the government of the Province of Quebec indicates that more than 1,300 lakes in that province are currently acid-stressed and in danger of destruction.

In Atlantic Canada, the prized Atlantic salmon is endangered by acid rain; nine salmon rivers in Nova Scotia have pH measurements below 4.7 and the fish have disappeared. Eleven other rivers are threatened and their salmon runs could disappear within 20 years. The acidity of precipitation in Newfoundland now ranges between pH 4.5 and 4.9 and there are serious concerns about effects on the province's timber resources and freshwater fish populations, including salmon stocks.

Acid rain is now being considered as a threat in parts of western Canada. Saskatchewan is concerned about sulphur emissions from Alberta and Manitoba and precipitation with a pH as low as 4.6 has been reported in the northern part of the province which is covered by the sensitive Canadian Shield. Recent reports have indicated that acid rain is falling also in British Columbia, particularly in the lower mainland where pHs as low as 4.5 have been recorded.

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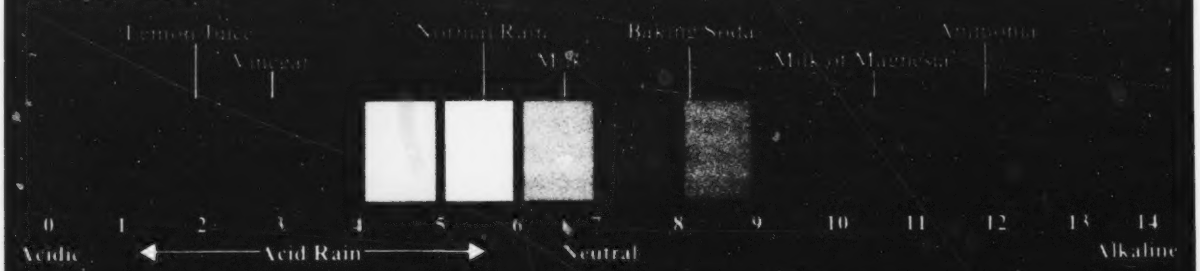
(1) The pH scale runs from zero (maximum acidity) to 14 (no acidity); pH 7.0 represents a neutral solution. The pH of normal rain, 5.6, is somewhat acidic because of chemical reactions involving carbon dioxide in the earth's atmosphere.

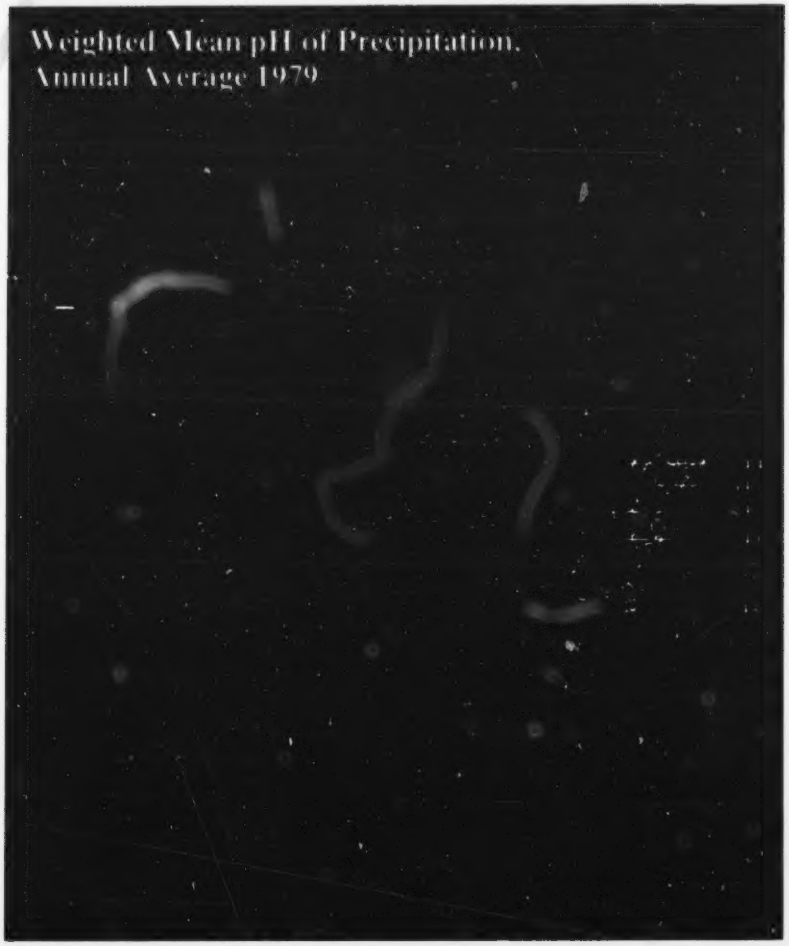
The pH Scale



In order to appreciate the effect of acid rain on our environment, an understanding of the pH scale is essential. The scale, used to measure soil or liquid acidity ranges from 0 (maximum acidity) to 14 (alkaline). A value of 7 is neutral.

Because the scale is logarithmic, there is a tenfold difference between one number and the one next to it. Therefore, a drop in the pH from 7 to 6 indicates that the acidity is 10 times greater, from 7 to 5 is one hundred times greater, and so on.

The pH of normal rain is 5.6, slightly acidic due to the presence of carbon dioxide in the earth's atmosphere.



Weighted Mean pH of Precipitation, Annual Average 1979

There is evidence also, in addition to a strong conviction on the part of many scientists, that acid rain poses a serious threat to all sectors of the Canadian environment, including forest ecosystems, agricultural crops, and man-made structures.

The forest industry is Canada's largest enterprise and is valued at about $20 billion a year. Annual exports total $12 billion, surpassing the combined revenues from agriculture, mining, fishing and fuels. About one million Canadian jobs depend directly or indirectly on the forest industry. The forest resource is an important source of revenue for almost every province in Canada. If, as many scientists suggest, acid rain will reduce forest productivity significantly in the long run, the cost to the Canadian economy will be substantial.

Agricultural productivity may also be affected by acidic precipitation. The effects are two-fold: first, there is the direct effect of dilute acid on plant foliage and, second, the effects on soil which necessitate increased production costs through addition of lime to fields to neutralize the acidity.

Acid rain and its precursors, sulphur oxides and nitrogen oxides, have a direct destructive effect on man-made materials. Building materials and statuary are seriously affected, incurring costs of hundreds of millions of dollars annually. It has been suggested also that perhaps one-half of automobile corrosion in Canada is due to acid rain. Thus, the total annual cost to Canadians from materials damage is enormous.

While there is no evidence that acid rain *per se* has a direct impact on human health, there is a concern on the part of health authorities that human health may be affected by this pollutant, at least indirectly. There is a virtual unanimity of expert opinion that sulphur and nitrogen oxides in the atmosphere have measurable and serious human health effects. Individuals who already are afflicted by various respiratory ailments are at greatest risk. Contamination of potable water supplies by heavy metals is also a major concern. The problem can emerge in three ways. First, heavy metals can be leached by acid rain from soil and rocks into groundwater. Second, acidified water can become contaminated by heavy metals leached from metal water pipes. Third, acid rain can cause the contamination of fish by toxic methyl mercury, a serious threat for those segments of the population who include large quantities of fish in their diet.

Emissions of sulphur oxides in North America total about 31.7 million metric tons (tonnes) annually;(1) 26.9 million tonnes (about 85 per cent) are produced in the United States while Canada produces 4.8 million tonnes. Emissions of nitrogen oxides in North America total 22.2 million tonnes per year with the United States producing 20.2 million tonnes (91 per cent) and Canada 2.0 million tonnes. Emissions of sulphur oxides have been projected to increase "modestly" in North America by the end of this century. This projection, however, may seriously underestimate future increases because of the uncertainties associated with the conversion of oil-fuelled industries to coal in the United States. Oxides of nitrogen are expected to increase by almost one-third by the year 2000, primarily as a result of the increased use of coal in the United States.

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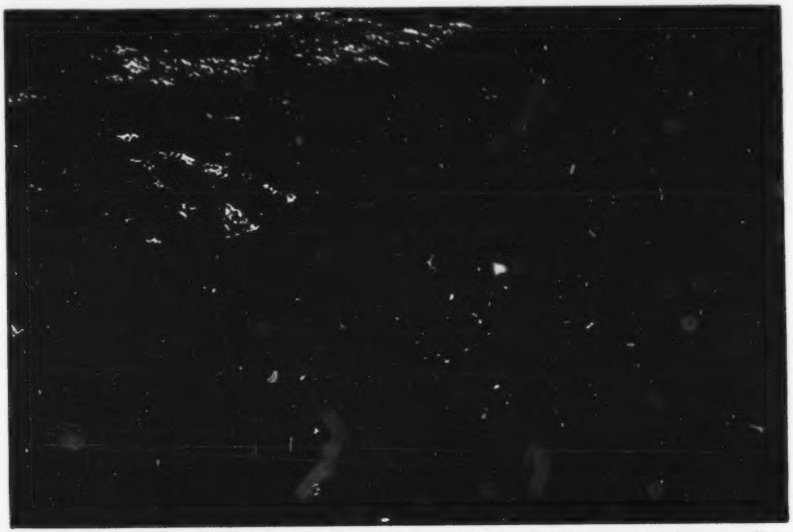
(1) A metric ton, or *tonne*, weighs 1000 kilograms (kg.), or 2,204.623 lb. A short *ton* weighs 2000 lb. Thus, 1 ton = 0.9072 tonne; 1 tonne = 1.1023 tons.

The meteorological patterns in eastern North America dictate that atmospheric pollutants can move over great distances within Canada and the United States, and also across the international border. Canada's acid rain thus originates from sources in both countries. Preliminary estimates suggest that about 3 to 4 times as much sulphur, on an annual average basis, moves across the border from the United States to Canada than moves in the opposite direction. A reasonable estimate of the U.S. contribution to Canada's sulphur-sourced acid rain is approximately one-half, with the other half originating from domestic emissions; in some sensitive areas, such as the Muskoka-Haliburton region of Ontario, the United States contribution is as high as 70 per cent.

The long-range transport of nitrogen oxides and the chemical reactions of nitrogen compounds in the atmosphere are, as yet, not well understood. It is estimated that some 30 per cent of eastern Canada's total acid rain is due to nitrates and Canadian authorities suspect that a "substantial" portion of this originates in the United States.

A major difficulty in effecting control of emissions from a particular industrial site is the lack of conclusive evidence linking acid rain in any specific area with a specific source. The purported polluter often will not admit responsibility and the regulatory authority is unable to demonstrate culpability with any certainty.

Current legislative instruments for the control of air pollution in Canada and in the United States focus their regulations on "ambient air quality" in the vicinity of a particular source or sources. It has been amply demonstrated, however, that an industry can be in full compliance with ambient air quality standards and still be a major contributor to the acid rain problem.



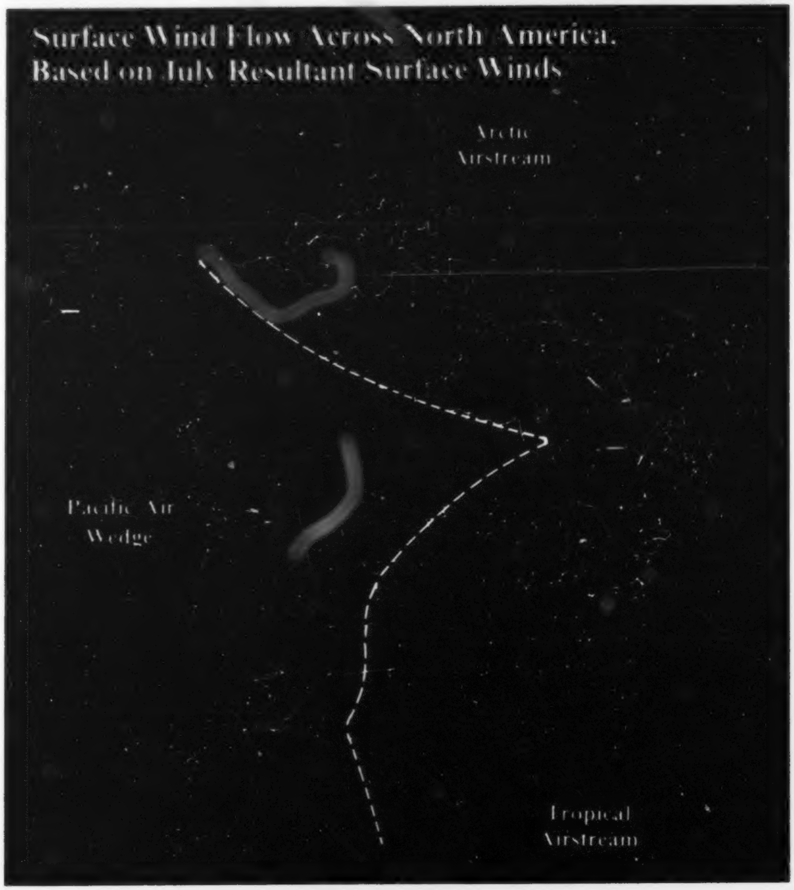
The granitic sub-soil of the La Cloche Mountain region in Ontario has made the lakes in the area particularly susceptible to the effects of falling acidic rain.

Two factors are involved. First, acidification of water in sensitive areas is a long-term process. The water in sensitive areas gradually becomes more acidic year by year as more acid is added in rain and snow. Eventually, the acidity in the system increases to a toxic level and the various species of fish and other aquatic organisms disappear. Second, the use of tall stacks dilutes and disperses the oxides of sulphur and nitrogen to a sufficient extent that local ambient air quality is not affected. However, the pollutants are now subject to long-range transport through the atmosphere and the sulphur and nitrogen oxides are transformed to sulphuric and nitric acids and are deposited as acid rain in areas far removed from the original source.

The international or transboundary aspect of acid rain is of especial concern to Canada because of the large output of emissions by United States industry and because the prevailing winds tend to carry substantial quantities of these pollutants into this country. The outlook for the future is clouded by the determination of the United States to decrease its dependence on foreign oil through increased utilization of domestic coal resources. The proposed conversion of many existing oil-fired power plants to coal without adequate environmental controls is especially worrisome; much of the coal to be used in these plants has a high sulphur content.

The Sub-committee understands and accepts the logic behind the decision of the United States to achieve energy independence through the use of domestic coal resources. However, we believe that the necessary pollution abatement measures are not inconsistent with the economic and energy goals of the United States. The long-term environmental and economic costs of uncontrolled air pollution will far exceed the illusory short-term gains deriving from ecologically unsound conversions to coal by U.S. industry.

A hopeful development in the bilateral problem of acid rain was the signing of a Memorandum of Intent on August 5, 1980 between Canada and the United States concerning transboundary air pollution.


Surface Wind Flow Across North America: Based on July Resultant Surface Winds

The Memorandum was intended as a preliminary step toward the development of a formal cooperative agreement on transboundary air pollution; formal negotiations commenced on June 23, 1981 in Washington, D.C.

The general public's perception and understanding of the acid rain phenomenon are issues which have occupied the Sub-committee's attention and concern throughout the course of its deliberations. Canadians are, in general, more aware of the acid rain problem than are citizens of the United States. This dichotomy stems from the fact that the United States is, to a large degree, a "donor" nation, and Canada a "receptor" of acid rain. Nevertheless, both countries will face enormous environmental damage from acid rain in the years ahead unless air pollutants, on both sides of the border, are successfully controlled.

The Sub-committee has encountered this perceptional problem during its travels in Canada and abroad. The Canada-United States scenario is mirrored by the situation between Scandinavia and the United Kingdom. Scandinavia is, in large measure, a receptor of acid rain sourced in SO_x and NO_x emissions in the United Kingdom and other heavily industrialized areas of Europe.

Within Canada there are also perceptional problems with the acid rain phenomenon. The citizens of Ontario have perhaps the highest perception in Canada of acid rain as a serious environmental problem. This is understandable because extensive areas of Ontario are very sensitive to acidification. In Quebec, however, the appreciation of acid rain is significantly lower although that province's total environment is perhaps more susceptible to damage from acidic precipitation than any other area in North America.

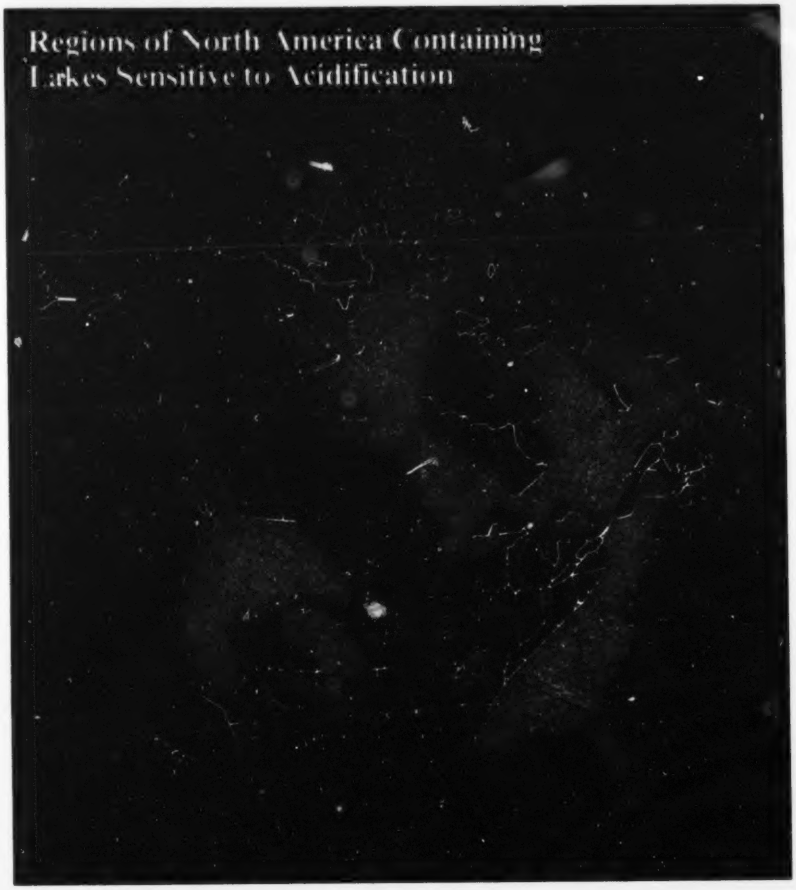
There are perceptional problems also between and among provinces in Western Canada and in the Atlantic region. The Sub-committee was particularly impressed by the appreciation of the issue and the concern expressed by representatives of the governments of Saskatchewan and Newfoundland; both provinces are primarily receptors of acid rain, part of which is sourced in neighbouring jurisdictions.

The Sub-committee was left with the impression that each of the producing provinces has been reluctant to take initiatives which entail more severe restrictions on its own emission sources than those imposed elsewhere. The past attitude of these provincial ministries appears to have been one of concern for their own environmental integrity without sufficient concern for the impact that their emissions have on neighbouring provincial environments.

The Sub-committee hopes that its hearings have increased the sense of national responsibility which we regard as essential to convince the United States that Canada is serious about acid rain.

A vitally important consideration in the acid rain problem is the time element. Although some observers maintain that there is no need for "precipitous" regulatory action, the available evidence suggests that continued pollutant loading of sensitive areas at current levels will result in progressive deterioration of the environment. Moreover, the effects will become extensive and irreversible over the next 10 to 20 years, particularly in aquatic ecosystems.

Throughout the course of our



Regions of North America Containing Lakes Sensitive to Acidification

deliberations, the Sub-committee was apprised of the need for more research on acid rain. There is clearly an urgent need to generate more scientific evidence on all aspects of the acid rain problem, including emission sources, atmospheric transport of pollutants, atmospheric chemical reactions and specific environmental effects. There is, however, a persistent danger that this legitimate need could be subverted into a substitute for the difficult decisions that ultimately will have to be taken. *A substantial body of respected scientific opinion already supports the conclusion that the best available technologies should be implemented as quickly as possible to control emissions at source.*

The Sub-committee recognizes that progress has been made in Canada to control acid rain-causing emissions. For example, the Ontario Government has placed a more stringent Control Order on the INCO Limited smelter in the Sudbury basin. Recently, Ontario Hydro has announced a $500 million program to reduce, by more than 40 per cent, emissions from certain of its coal-fired power plants.

The Federal Government also has made progress in the fight against acid rain. The **Clean Air Act** has been amended to enable the Minister of Environment Canada to control emissions which affect the health, welfare or safety of persons in another country. National Emission Guidelines directed toward new coal-fired thermal power plants were adopted under the **Clean Air Act** in April 1981. In October 1980, the Minister of Environment Canada announced that the government would spend $41 million between then and 1984 to combat acid rain. The Canadian Government has entered into negotiations with the United States Government to develop a bilateral cooperative agreement on air quality to deal effectively with transboundary air pollution. In parallel with this effort, the government has pursued an extensive public awareness campaign on acid rain in the United States and in Canada.

It is the Sub-committee's view, however, that progress has been too slow and that the provincial and federal environment departments and ministries have acted only reluctantly and cautiously in the past to reduce acid rain-causing emissions. *Much more aggressive emission control strategies are essential at all levels to deal with the problem of acid rain.*

Industry in Canada has not always distinguished itself in the environmental area. Some industries have excellent records in emission control but others have effected no controls whatever. Too often, individual companies have cited costs as prohibitive factors in effecting controls. This position is unacceptable to the Sub-committee.

Equally unacceptable is the claim by some industries, including some Crown corporations, that their emissions are negligible in the total North American context. The acceptance of this spurious philosophy will effectively doom the Canadian environment to ultimate destruction. Canadian emissions of SO_x and NO_x have to be substantially reduced. Non-ferrous smelters, coal-fired power plants, and the transportation sector are appropriate targets for more stringent regulatory controls.

The Sub-committee recognizes the vital importance of transboundary issues in solving the Canadian, and North American, acid rain problem. The Memorandum of Intent is a promising first step in the development of an effective North American environmental accord. The Sub-committee is not yet persuaded that there is any reason for great optimism however. The practical success of any future agreement will depend upon the willingness of the Canadian and United States governments to construct and apply effective regulatory instruments to control atmospheric emissions.

There is ample evidence from past experience in both countries to cause deep concern that the appropriate regulations may be neither created nor enforced. *A successful control program requires a determined political will; the lack of that political will may be the single most important impediment to combatting acid rain.*

The Sub-committee believes that Canada must adopt a strongly positive, and at times aggressive, posture in negotiations with the United States. We do not, however, see the fight against acid rain as a confrontation between the two countries. Rather, we take the view that the issue is one of rational cooperation between two governments striving to build upon a base of mutual and enlightened self-interest.

The Sub-committee on Acid Rain has received and studied extensive documentation on all aspects of this critically important problem. We received evidence from 113 witnesses at public hearings across Canada and at briefing sessions in Ottawa. The Sub-committee heard the testimony of concerned Canadians from all parts of the country and from all walks of life.

Witnesses who appeared before us included specialists in the fields of fisheries, agriculture, health and environmental management. Scientists and officials from the petroleum, mining, electrical and non-ferrous smelting industries gave us the benefit of their experience and expertise. We heard from numerous environmental groups who provided valuable insights into the total acid rain problem and the urgent need for controls.

The Sub-committee was pleased to receive testimony from the academic community, from university professors and students alike. We were disappointed, however, that we did not receive more representations from university researchers whose independent views on acid rain would have been of great interest to the Sub-committee.

We were particularly gratified to hear evidence from concerned high school students from New Brunswick and Nova Scotia at our Halifax hearings. The Sub-committee believes strongly that the involvement of young Canadians in the fight to protect our environment is absolutely essential for a successful resolution of the acid rain problem.

The Sub-committee met with nine members of the United States Senate and six members of the House of Representatives during our visit to Washington, D.C. Our discussions were forthright and fruitful and we were impressed by the concerns expressed for the safety of both the Canadian and United States environments. One tangible outcome of these discussions was a letter of support from Representative Richard L. Ottinger of New York to the Chairman of the Sub-committee and co-signed by 90 U.S. Congressmen.

The Sub-committee met with senior U.S. government officials from the Environmental Protection Agency, the Department of Energy, and the President's Council on Environmental Quality. We were privileged also to receive briefings from the Environmental Law Institute, the Natural Resources Defence Council Inc., and the Alliance to Save Energy.

In Ottawa we received detailed briefings from Mr. Eric Lykke of the Norwegian Ministry of the Environment and from Mr. J. Stanovnik, Executive Secretary of the Economic Commission for Europe. During our trip to the United Kingdom and Sweden, the Sub-committee held in-depth discussions with senior government officials and research scientists and administrators in both countries.

It is the Sub-committee's view, based on our extensive investigations, that informed Canadians and Americans believe there is a critical need for positive action to combat the depredations of acid rain on the North American environment. We hope and trust that this report will make a constructive contribution towards that end.

SOURCES OF ACID RAIN

The anthropogenic — that is, man-made — sources of acid rain are sulphur oxides (SO_x) and nitrogen oxides (NO_x), which are released into the atmosphere as by-products of man's various industrial activities. After the sulphur and nitrogen oxides are discharged into the atmosphere, they are subject to a variety of chemical reactions as a result of contact with atmospheric moisture. These reactions are numerous and complex and are influenced by such diverse factors as intensity of sunlight and availability of water, hydrocarbons, oxygen and pollutants such as heavy metals.

A complex chemical process converts the oxides of sulphur and nitrogen into sulphuric acid (H_2SO_4) and nitric acid (HNO_3), respectively. These acids ultimately fall to earth in precipitation of various kinds, including rain and snow. Pollutants also fall to earth as dry deposition where they may be converted to acids upon contact with water.

North America produces enormous quantities of anthropogenic SO_x and NO_x emissions. These emissions are summarized in Table 1. Current emissions total about 22.2 million tonnes of oxides of nitrogen and 31.7 million tonnes of sulphur oxides. As would be expected, the United States emits far more of both types of pollution than does Canada. Emissions of NO_x by the U.S.A., for example, are about ten times greater than the Canadian output, 20.2 million tonnes versus 2.0 million tonnes.

For SO_x emissions, however, the United States:Canada ratio is only about 5.6:1, indicating that Canada on a per capita basis is proportionately the greater offender. About 40 per cent of Canada's annual SO_x emissions, 2.0 million tonnes, emanate from non-ferrous smelters which process high-sulphide ores to produce such metals as nickel and copper.

The U.S. non-ferrous smelting industry produces about 1.8 million

Table 1: Current Nationwide Emissions of SO_x and NO_x in the United States and Canada

	U.S.A. 1980 (Estimated)		Canada 1979		Total	
	NO_x	SO_x	NO_x	SO_x	NO_x	SO_x
Utilities	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Industrial Boilers, Process Heaters, Residential Commercial	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Non-ferrous Smelters	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Transportation	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Iron Ore Processing				[illegible]		[illegible]
Other		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total	20.2	26.9	2.0	4.8	22.2	31.7

[illegible]

Annual Sulphur Dioxide (SO_2) Emissions in North America

tonnes of sulphur dioxide each year. The non-ferrous smelters in the United States producing SO_2 are primarily copper smelters located in the western and southwestern states, geographically removed from the sensitive receptor areas in eastern North America.

Thermal power plants produce about two-thirds of total U.S. domestic SO_x emissions. In 1980, these plants emitted an estimated 17.7 million tonnes of pollutant. Canadian thermal power plants produced 0.7 million tonnes of SO_x in 1979, about 15 per cent of the Canadian total for that year.

Another important source of SO_x emissions in North America is general fuel combustion by industrial, commercial and residential users. These sources contribute about one-quarter of the continental output of SO_x. Again, the United States: Canada ratio, at about 6.5:1, demonstrates that Canadians produce more sulphur oxide pollution from these combined sources, on a per capita basis, than do our southern neighbours.

Emissions of oxides of nitrogen in North America are concentrated in the eastern part of the continent: almost 19.1 million tonnes of the total output, or about 85 per cent, come from this densely populated and heavily industrialized region. Here, the United States: Canada ratio is about 15:1, and almost one-half of the combined emissions of NO_x come from the transportation sector. Another 25 per cent of combined U.S.-Canada NO_x emissions come from thermal power plants, and the remainder is contributed by industrial, commercial and residential fuel combustion.

ACID RAIN IN CANADA

The Sub-committee has received evidence from all parts of Canada on the acid rain problem. In most instances, we were fortunate enough to receive evidence from provincial environment ministries which outlined specific provincial concerns; representatives from the Provincial Governments in Newfoundland, Prince Edward Island, Nova Scotia, New Brunswick, Ontario and Saskatchewan testified before the Sub-committee. Some provincial ministries chose not to appear before the Sub-committee in spite of the fact that we held public hearings in their provinces. The Ministries of Environment of Quebec and Alberta are included in this category. Ministries in Manitoba and British Columbia also did not present briefs or offer testimony to the Sub-committee. We regard this as an unfortunate circumstance, one that made more difficult our task of addressing the concerns of Canadians from all parts of the country.

All ten Canadian provinces have at least some cause to be concerned about the effects of acid rain although it is clear that some areas of the country, particularly the eastern provinces, are in a more critical situation than others. In this part of the report we shall provide an overview of the acid rain problem, to the extent that this is possible, for each province.

Table 2: Annual Emissions of Sulphur Dioxide and Nitrogen Oxides in Canada, by Province, 1976-1977

Province	Sulphur Dioxide	Nitrogen Oxides
Newfoundland	[illegible]	[illegible]
Prince Edward Island	16	[illegible]
Nova Scotia	[illegible]	[illegible]
New Brunswick	[illegible]	64
Quebec	[illegible]	[illegible]
Ontario	[illegible]	[illegible]
Manitoba	[illegible]	84
Saskatchewan	[illegible]	130
Alberta	[illegible]	[illegible]
British Columbia	[illegible]	[illegible]
Northwest Territories	[illegible]	[illegible]
Yukon	N.A.**	N.A.

[illegible]

Newfoundland

Newfoundland does not itself produce significant quantities of acid rain-causing emissions. Rather, to use the provincial Environment Ministry's own words, "Newfoundland is at the end-of-the-funnel insofar as this pollutant 'fall-out' is concerned." The province lies in the path of prevailing winds and weather systems that flow from northeastern and central North American industrialized areas.

The geological structure of the island of Newfoundland is complex but the rock formations tend to be granitic and devoid of buffering chemicals. Similarly, Labrador, which is covered by the Canadian Shield, is also sensitive to acid rain. Many areas of the province, particularly in the central part of the island, contain large deposits of peat which tend to make the soil and water acidic. Many of the freshwater systems have a high dissolved organic acid content. Much of the province is therefore sensitive to the effects of acid rain.

Precipitation falling in Newfoundland is typically acidic, ranging from a low of pH 4.5 in the southwest to 4.9 in the northeast. On the Avalon Peninsula, the precipitation pH is 4.7, and pH values in the south-central region of the island are estimated to be between 4.5 and 4.7. In Labrador, the situation is somewhat better, with precipitation ranging from pH 4.7 in the south to higher than pH 5 in the north.

The data base on effects from acid rain in Newfoundland is presently insufficient to permit an assessment of damage. However, it is clear that there is reason to be concerned about the future safety of the province's timber resources and freshwater fish stocks. The forest ecosystem of Newfoundland is similar to that in Scandinavia where there are suggestions that acid rain has damaged forest productivity.

The water quality of 13 streams in the eastern part of the island has

Table 3:

TEN LARGEST SOURCES

of Sulphur Dioxide (SO_2) for Canada

		tonnes/year
1	**INCO Limited** Copper Cliff, Ontario	866,000
2	**Noranda Mines Ltd.** Noranda, Quebec	538,000
3	**INCO Limited** Thompson, Manitoba	359,000
4	**Hudson Bay Mining and Smelting Co. Ltd.** Flin Flon, Manitoba	212,000
5	**Ontario Hydro, Lambton Station** Courtright, Ontario	160,000
6	**Ontario Hydro, Nanticoke Station** Walpole Township, Ontario	155,000
7	**Algoma Steel Corporation Ltd.** Wawa, Ontario	141,000
8	**Falconbridge Nickel Mines Ltd.** Falconbridge, Ontario	122,000
9	**Suncor Inc. (Oil Sands Division)** Fort McMurray, Alberta	93,000
10	**Ontario Hydro, Lakeview Station** Mississauga, Ontario	91,000

been monitored since 1977. The pH levels vary from 5.3 to 6.1. While these levels are not yet critical they are approaching the point where fish populations, particularly brook trout, could be threatened. Most of the fresh waters of the island and of Labrador have calcite sensitivity indices greater than three, indicating that they are sensitive waters with low buffering capacity. The Minister of Environment for Newfoundland expressed concern to the Sub-committee that "further increases in acidic pollutants being transported into the Province will...(cause)...a decrease in salmon and trout productivity in many water bodies in Newfoundland and southern Labrador."

Prince Edward Island

The pH of rainfall in Prince Edward Island is about 4.5, a level which is typical throughout the Atlantic region. No damage from acid rain has as yet been observed in this province but the provincial government has voiced the same concern about the future as have the other provinces.

The Island's soils are naturally acidic; virgin soils measure from pH 4.2 to 4.6 while the average pH of agricultural soils ranges from 5.1 to 6.7. Liming of agricultural soils is a standard practice in Prince Edward Island. The cost of liming soils has increased slightly in response to current levels of rainfall acidity.

The surface waters of the province have a significant capability for neutralizing acidity because of substances leached from the soil. The relationship between the naturally acid soils and the leaching of buffering materials into streams is a complex one. The Provincial Government has expressed concern that this renewable but limited buffering capacity might be outstripped by the increasing burden of precipitation acidity.

The aquatic resource of most concern is sport fish, the acid-sensitive trout and salmon. There is also concern for the quality of groundwater on the Island because the province's population is entirely dependent on groundwater for potable and process water supplies.

Nova Scotia

The pH of precipitation falling in Nova Scotia averages about 4.7; in the western part of the province the precipitation pH is 4.5, in the central part about 4.6, and then increases from 4.7 to 5.0 as one progresses northward through Cape Breton. In the early 1950s, the pH of rain and snow falling in Nova Scotia was 5.7.

Nova Scotia is a significant producer of acid rain-causing emissions in the Atlantic area. Estimates for SO_2 emissions in 1980 total 178,544 tonnes; NO_x emissions estimates amount to 76,900 tonnes. The major source of sulphur and nitrogen emissions is the Nova Scotia Power Corporation which produces electricity from six thermal-powered generating stations. These sources produce about 115,000 tonnes of SO_2 annually. Conversion of oil-fired plants to coal and the construction of new coal-fired generators at Lingan in Cape Breton could result in a doubling of both pollutants by the year 2000 if no emission control devices are installed.

Nova Scotia also receives significant amounts of acid rain-causing emissions from outside the province. It is estimated that 80 per cent of the 52,000 tonnes of non-marine sulphur (104,000 tonnes of SO_2) depos-

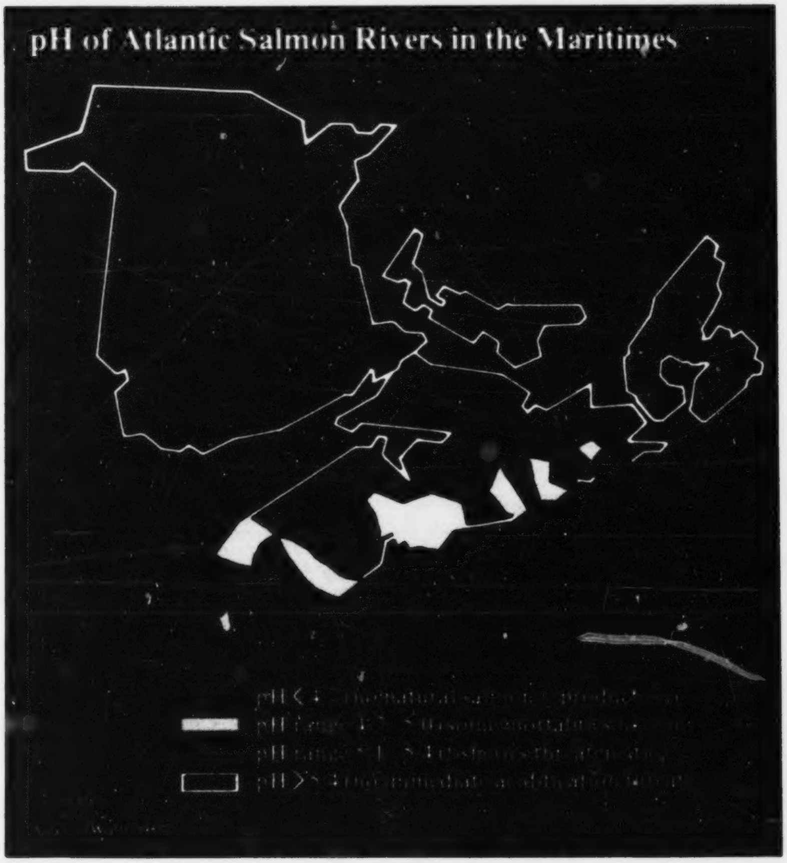

pH of Atlantic Salmon Rivers in the Maritimes

Table 4: Major Sulphur Dioxide (SO_2) Sources: Atlantic Region*

	tonnes/year
1. Stationary Fuel Combustion	203,000
2. Nova Scotia Power Corporation	115,000
Point Tupper Generating Station, Point Tupper (37,000)	
Lingan Generating Station, Cape Breton (24,000)	
Trenton Generating Station, Trenton (17,000)	
Tufts Cove Generating Station, Dartmouth (14,000)	
Water Street Generating Station, Halifax (12,000)	
Glace Bay Generating Station, Glace Bay (11,000)	
3. New Brunswick Power Commission	85,000
Coleson Cove Generating Station, Saint John (50,000)	
Grand Lake Generating Station, Minto (25,000)	
Courtenay Bay Generating Station, Saint John (10,000)	
4. Petroleum Refineries (6)	82,000
5. Halifax City Area	50,000**
6. Sulphite Pulp Plants	16,000
7. Brunswick Mining and Smelting Corporation, Belledune, New Brunswick	[illegible]

ited in Nova Scotia each year originates from outside the province. The same estimate, stated differently, indicates that Nova Scotia sends approximately 157,000 tonnes of provincially-emitted sulphur dioxide to other parts of the Atlantic region.

Nova Scotia has an estimated 9,400 lakes, many of which are poorly buffered by natural alkalinity. Nine river systems on the southwest and eastern shores of the province are now devoid of reproducing populations of Atlantic salmon; the pH of these rivers is reported to be below 4.7. There is evidence that 13 more salmon rivers are bordering on extinction and that an additional nine are threatened.

New Brunswick

The average pH of precipitation in New Brunswick is about 4.6, approximately ten times more acidic than normal precipitation. The provincial Ministry of Environment estimates that roughly one-third of the province's surface waters are located in zones of poorly buffered soils and parent materials.

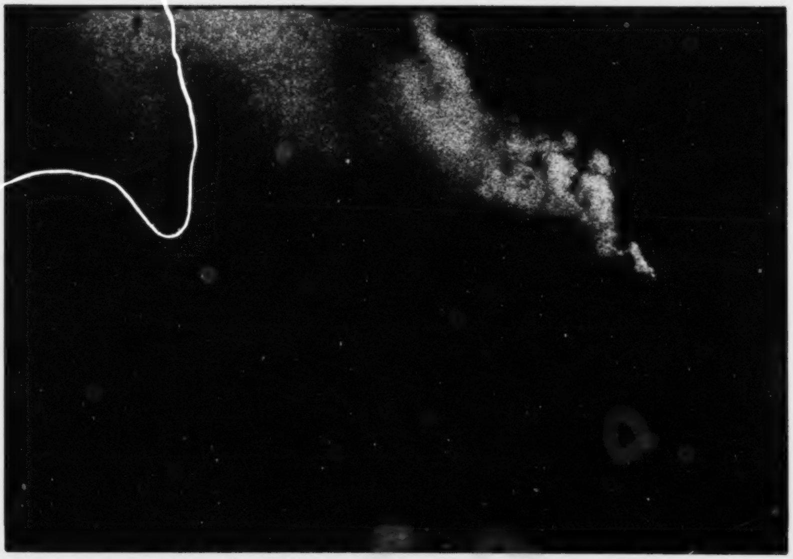
There is as yet no persuasive evidence that a detrimental degree of acidification of surface waters has yet occurred but a number of lakes are considered to be sensitive to further acidification over the long term. There is also a concern that continued rainfall acidity of pH 4.6 or lower could have potentially serious impacts on New Brunswick's agriculture and forest resources.

The province is a significant producer of sulphur oxides and nitrogen oxides in the Atlantic region. The New Brunswick Power Commission's thermal power plants, currently largely oil-fired, produce about 85,000 tonnes of SO_2 annually. The Commission's Coleson Cove Generating Station in Saint John produces 50,000 tonnes of SO_2 per year and is the largest point source for sulphur dioxide in the Atlantic region. A number of the Commission's oil-fired plants, including Coleson Cove, are under consideration for conversion to coal with financing possibly being provided under the National Energy Program. These projected conversions have raised considerable concern for air quality in the Atlantic region because New Brunswick coal is extremely high in sulphur content, containing up to 8 per cent sulphur.

Quebec

The pH of precipitation falling on Quebec measures about 4.5 in the south and increases to 5.0 around the centre of the province, and to 5.5 to 6.0 in the northern regions. Most of the province of Quebec is highly sensitive to acidic precipitation; in the area south of the St. Lawrence River and a small region on the Ontario border the soils are well buffered and are not sensitive to acid rain.

The Sub-committee regrets that



The copper smelter at Noranda in Quebec is Canada's second largest point source of SO_2 emissions. No control technology is currently in use.

the Ministry of Environment of Quebec chose not to attend our public hearings in Montreal and provide us with information on the acid rain problem in that province. It is quite clear that Quebec has much to lose from the onslaughts of acid rain. The freshwater fisheries and forest resources stand at risk from cumulative acid loadings. The Sub-committee was advised that the contamination of fish by mercury is an area of special concern, particularly for Quebec's aboriginal populations who live off the land in close harmony with nature.

Quebec has a number of major sources of acid rain-causing pollutants. The two non-ferrous smelters operated by Noranda Mines Limited emit a total of 604,000 tonnes of sulphur dioxide each year. The copper smelter at Noranda, which has no emission control technology in place, emits 538,000 tonnes of sulphur dioxide annually and is the second largest point source of SO_2 in Canada.

Table 5: Major Sulphur Dioxide (SO_2) Sources: Quebec*

	tonnes/year
1. Noranda Mines Ltd. Noranda [illegible] Murdochville [illegible]	[illegible]
2. [illegible]	[illegible]
3. [illegible]	[illegible]
4. [illegible]	[illegible]
5. [illegible]	[illegible]
6. [illegible]	[illegible]

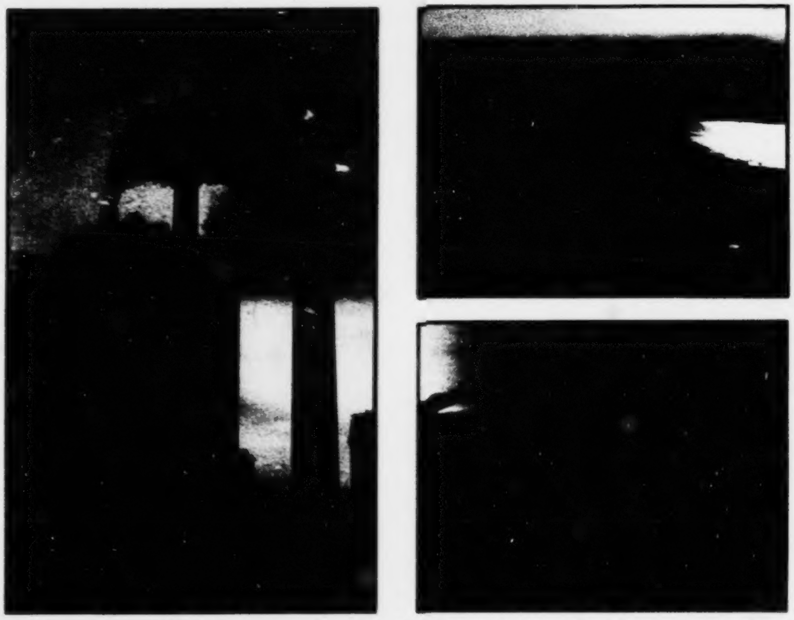
Ontario

The impact, real and potential, of acid rain on Ontario is very well known. The pH of precipitation falling on Ontario is about 4.5 on average, but even higher levels of acidity have been recorded. Parts of Ontario, especially the tourist havens of Muskoka-Haliburton, are extremely sensitive to acidic precipitation. Hundreds of lakes in the province have been rendered fishless by acid precipitation and a staggering total of 48,000 lakes is threatened unless corrective action to control sulphur and nitrogen emissions is started immediately.

In addition to its lake systems, Ontario has much to lose to acid rain in the forestry and agriculture sectors. Much of Ontario's prime agricultural land has been damaged and made acidic by heavy nitrogen fertilization to support continuous cropping of corn and these areas are particularly sensitive to increased acid loadings.

The Ontario Ministry of the Environment fully recognizes the threat from acid rain. The ministry's Senior Assistant Deputy Minister, J. Walter Giles, made the following statement to the Sub-committee: "It is extremely important in terms of saving the aquatic life of Ontario lakes and waterways as well as ensuring the health of our province's valuable forest industry that we in North America get on with the job of acid rain abatement immediately."

Although Ontario is a victim of



A tremendous effort is required to combat the emission of acid rain producing pollutants in heavily industrialized areas. Ontario Hydro's three thermal power stations, Lakeview (left), Lambton and Nanticoke (bottom right), combine to produce over 400,000 tonnes of sulphur dioxide (SO_2) per year. Much of this pollution will travel many miles from its source.

sulphur and nitrogen oxides produced outside the province's borders, this most-heavily industrialized province is the major emitter of acid rain-causing pollutants in Canada. The Sub-committee is aware that Ontario has enforced significant reductions in air pollutants over the past decade, but a much greater effort is necessary. The INCO Limited smelter at Copper Cliff is the largest point source of sulphur dioxide in Canada, emitting 866,000 tonnes per year. Much of this pollution travels over long distances to produce acid rain in other parts of Canada and in the United States.

Other major pollution sources include Ontario Hydro's thermal power plants (410,000 tonnes of SO_2 per year), the Algoma Steel Corporation Limited iron ore sintering plant at Wawa (141,000 tonnes per year), and the Falconbridge Nickel Mines Limited smelter at Sudbury (122,000 tonnes per year).

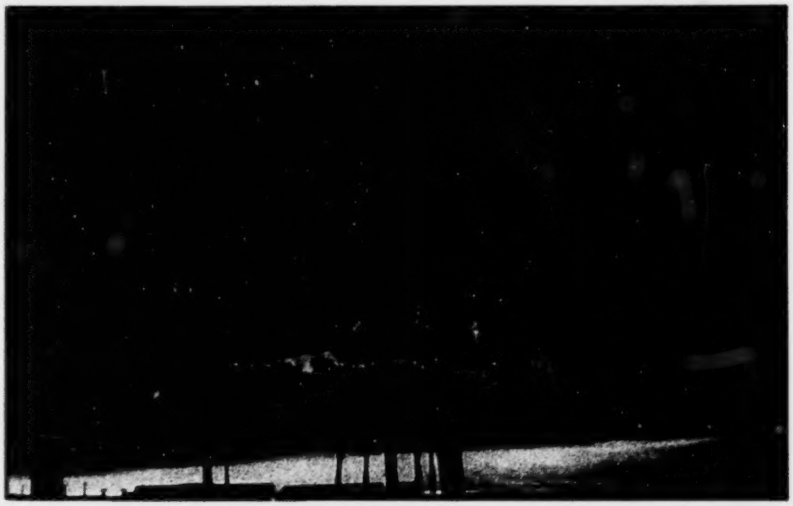
The Algoma Steel Corporation Limited plant at Wawa is one of the ten largest emitters of sulphur dioxide in Canada; Algoma's Wawa emissions are equal to approximately 75 per cent of total SO_2 emissions from the entire country of Norway. The Sub-committee was unable to study this particular source in detail; it is abundantly clear, however, that emissions from this plant must be drastically reduced as part of Canada's acid rain control strategy.

Manitoba

Study of acid rain in Manitoba is presently at a preliminary stage and there is only limited information available. Precipitation in the province, in most monitored regions, typically measures pH 5.6 or higher. At one provincial monitoring site in east-central Manitoba (Island Lake) the pH of rainfall ranges from 5.1 to 5.3.

At least half of the province is potentially sensitive to acid rain because the Canadian Shield cuts diagonally across the central area. Lakes in this region would presumably have low buffering capacity but no problems appear to have shown up as yet.

Manitoba has two major point sources of sulphur dioxide: the Hudson Bay Mining Company Limited copper-zinc smelter at Flin Flon produces 212,000 tonnes of SO_2 annually; the INCO Limited nickel smelter at Thompson emits 359,000 tonnes of SO_2 each year. Neither smelter has installed any sulphur-



Sunset at the Falconbridge Nickel Mines smelter at Sudbury only serves to dramatize more vividly the effects of unchecked pollution emission.

Table 6: Major Sulphur Dioxide (SO_2) Sources: Ontario*

		tonnes/year
1	INCO Limited Copper Cliff, Ontario	[illegible]
2	Ontario Hydro	[illegible]
	Lambton Station, Courtright [illegible] Nanticoke Station, [illegible] Lakeview Station, Mississauga [illegible]	
3	Toronto Metropolitan Area	[illegible]**
4	Algoma Steel Corporation Ltd. Wawa, Ontario	[illegible]
5	Falconbridge Nickel Mines Ltd. Falconbridge, Ontario	122,000
6	Petroleum Refineries	[illegible]
	Imperial Oil Limited, Sarnia [illegible]	
7	Hamilton City Area	[illegible]
8	St. Catharines-Niagara Area	[illegible]
9	Sulphite Pulp Plants	[illegible]

containment technology but each company has been requested by the provincial environment ministry to study appropriate abatement technologies.

Saskatchewan

The Saskatchewan Ministry of Environment informed the Sub-committee that there is no conclusive evidence indicating that the province has an acid precipitation problem at the present time. There is concern, however, about the acidity of precipitation falling in the Cree Lake area in northern Saskatchewan, a region covered by the sensitive Precambrian Shield. The pH of precipitation in this area has been measured as low as 4.6. Dr. U.T. Hammer, in a report prepared in 1980 for the Saskatchewan Environmental Advisory Council, concluded that acid rain is currently falling in the Precambrian Shield area and will eventually cause environmental damage there.

Saskatchewan is not a major source of acid rain precursors but the province's coal-fired generating stations do emit significant quantities of SO_2 and NO_x; in 1980 the thermal power sector emitted 32,000 tonnes of SO_2 and about 36,000 tonnes of NO_x. By 1990, these levels could rise to 66,600 tonnes and 82,200 tonnes, respectively, if no emission control devices are used.

Saskatchewan's greatest concern is for SO_2 and NO_x produced in Alberta to the west and, to a lesser extent, in Manitoba on its eastern border. The petroleum industry in Alberta poses the greatest threat, especially the projected developments in the oil sands extraction industry at Fort McMurray and Cold Lake. Saskatchewan, itself, will pursue heavy oil development in the Lloydminster area and this enterprise will increase the province's SO_2 emission levels significantly. The major concern with Manitoba is the uncontrolled SO_2 emissions from the non-ferrous smelter operated by Hudson Bay Mining and Smelting Company Limited at Flin Flon.

The principal worry about acid rain in Saskatchewan is the effect on recreational and commercial fisheries in the northern third of the province. There is limited concern about the effects of acid rain on the forest industry because the economically valuable stands are located south of the sensitive Shield area. Similarly, Saskatchewan's agriculture is located in the southern part of the province where the soils are well-buffered against acidic precipitation.

The provincial Department of Environment is also concerned that Saskatchewan, and western Canada in general, is not receiving adequate attention from the Federal Government. Mr. L.J. Lechner, Director of the Department's Air Pollution Control Branch, stated that: *"With the focus of federal research efforts on the problems in eastern Canada, there is a danger that considerable research expertise in the federal government will not be available to address western concerns." The Sub-committee concurs with Saskatchewan Environment's concern in this matter and we urge Environment Canada to give serious consideration to this issue.*

Alberta

Alberta is an area of special interest for the Sub-committee because of the rapid expansion of that province's economy. While there is not

No sulphur containment technology has been installed at Inco's nickel smelter at Thompson, Manitoba which emits 359,000 tonnes of SO_2 annually.

presently any conclusive evidence that acid rain is consistently falling in Alberta, the Sub-committee received numerous expressions of concern about the direct effects of current levels of sulphur emissions in the province and the potential for an acid rain problem in the future if, as expected, sulphur and nitrogen emissions increase dramatically. Soils and water bodies in the province are generally well-buffered against acidic precipitation although the Canadian Shield covers the northeast part of the province.

The major source of sulphur dioxide in Alberta is the natural gas processing industry: annual emissions are about 326,000 tonnes. There are more than 40 gas processing plants scattered around southern and central Alberta with the highest concentration in the Calgary area. Oil Sands plants are the second-largest source of SO_2 in Alberta; in 1980, these plants produced about 134,000 tonnes of this pollutant.

The principal concerns about SO_2 emissions in Alberta include the effect the pollution might have on sensitive areas in northern Saskatchewan as a result of long-range transport, and the possible association between sulphur deposition in areas of Alberta where selenium is deficient and a selenium-deficiency condition in cattle known as "white muscle disease".

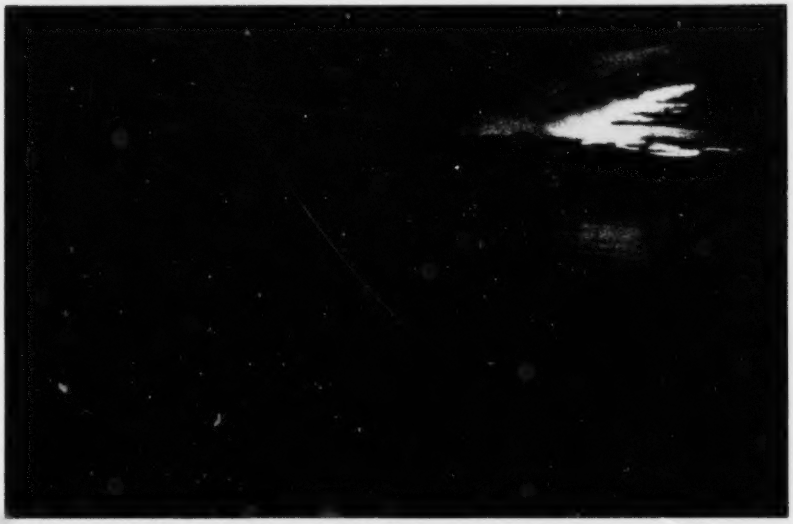
The acid rain problem in Alberta will be discussed in more detail in a separate section of this report.

British Columbia

Recent studies have shown that acid rain is falling in parts of British Columbia. Precipitation monitoring stations in the Vancouver area have measured rainfall pH at 4.9, about four or five times as acidic as normal rainfall. The acidity of rainfall measured by the University of British Columbia's Faculty of Forestry at the Haney Research Centre, a 13,000-acre research and demonstration forest just east of Vancouver, is about pH 4.5, more than 10 times as acidic as normal rainfall.

The Lower Mainland and southern coastal regions of British Columbia are sensitive to acid rain because the geological structure of the area lacks buffering capacity. At the present time, however, it does not appear that the pH of lakes and streams has fallen to a dangerous level. There is concern, however, that the accumulation of acid in snow over the winter period could produce episodes of "acid shock" during spring runoff in some areas. This can cause a rapid drop in the pH of part of a river or lake and could detrimentally affect fish reproduction.

There is no consensus about the source of British Columbia's acid rain. It is possible that local industries and motor vehicles are responsible but there is a theory that some, at least, is due to large polluted air masses drifting across the Pacific Ocean from Japan.



Acidic materials suspended in the Arctic atmosphere produce a severe haze.

Northwest Territories and Yukon:

Northern Canada is an area of special concern with respect to acid rain. The problems in the Territories are different from those in the more southerly parts of the country. Although deposition of acidic materials in the North is significantly lower than it is in eastern Canada, for example, the northern environment is believed to be extremely sensitive to pollution of all kinds. Soil cover in the North is very thin and large areas of the region are covered by sensitive bedrock.

Over much of the North there is little or no precipitation; the Canadian Arctic is typically referred to as a "cold desert". Nonetheless, acidic materials do invade the region and remain suspended in the atmosphere during the winter months as aerosol particulates. This gives rise to a severe problem in the form of haze which restricts visibility in the Arctic. This haze, together with a buildup of carbon dioxide in the Arctic atmosphere, has raised concerns about climatic changes, possibly leading to a warming trend in the region.

The phenomenon of "acid rain" may be extremely severe in the Arctic. The spring melt period in the North lasts for only about one week. Thus, all the acidic materials which have built up over the long winter are released into the environment in a very short period. The impact of this acid shock has not yet been adequately assessed.

The major source of acidic materials in the North is the Soviet Union; eastern North America is also a source area of concern. In the southern part of the Northwest Territories, near the Saskatchewan border, there is apprehension about the potential impact of emissions from the oil sands developments in Alberta.

Numerous research projects related to acid rain and other forms of pollution are underway, or planned, in Northern Canada. The problem here is similar to that expressed by witnesses from western Canada; *the understandable preoccupation of federal authorities with the impact of acid rain in eastern Canada has made it difficult to allocate adequate funding and manpower to northern studies. The Sub-committee is concerned about this problem and urges the Federal Government to re-examine its research priorities in this area.*

Table 7: Major Sulphur Dioxide (SO_2) Sources: North-west Region*

		tonnes/year
1.	INCO Limited Thompson, Manitoba	359,000
2.	Natural Gas Processing Plants	343,000
	Aquitaine Co. of Canada, Ram River, Alta (88,000)	
	Westcoast Transmission Co. Fort Nelson, B.C. (51,000)	
	Chevron Standard, Kaybob South, Alta (26,000)	
	Shell Canada, Pincher Creek, Alta (19,000)	
	Gulf Oil Canada, Rocky Mountain House, Alta (14,000)	
3.	Hudson Bay Mining and Smelting Co. Ltd. Flin Flon, Manitoba	212,000
4.	Oil Sands Plants	134,000
	Suncor Inc., Fort McMurray, Alta (93,000)	
	Syncrude Canada Ltd., Fort McMurray, Alta (41,000)	
5.	Electrical Power Generation	105,200**
6.	Petroleum Refining Plants (9)	26,000
	Manitoba (1) (5,000)	
	Saskatchewan (2) (4,000)	
	Alberta (6) (17,000)	
7.	Edmonton City Area	24,000***
8.	Winnipeg City Area	14,000****

* [illegible]

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Source: Canada Department of Environment, Air Pollution Control Directorate, 198[illegible]

EMISSION TRENDS: PAST AND FUTURE

Emissions of SO_x and NO_x in North America have increased greatly since the early 1950s, coincident with population growth, heavier resource utilization, industrial expansion, and the proliferation of the private automobile as a means of transportation.

In the eastern United States, for example, SO_2 emissions doubled from just under 10.9 million tonnes in 1950 to about 22.7 million tonnes in 1965 and then essentially stabilized at that level. In eastern Canada, however, current SO_2 emissions, at about 4.1 million tonnes, are at the same level as in 1955. Emissions of SO_2 peaked in 1965 at just under 5.5 million tonnes and then declined to the lower level experienced currently as a result of significant reductions in emissions from Canada's copper-nickel smelting industry.

NO_x emissions have increased in both the United States and Canada in all areas over the 1950-1978 period. Emissions in the eastern United States had increased to more than 17.3 million tonnes in 1978 from the 1950 level of 6.4 million tonnes. In eastern Canada, NO_x emissions grew from a level of less than 0.5 million tonnes in 1955 to just under 1.4 million tonnes in 1977. In eastern North America as a whole, the major portion of NO_x emission increases was from thermal power plants and the transportation sector.

Concurrent with the growth in SO_2 and NO_x emissions over the past 40 years has been a substantial increase in the height of stacks on thermal power plants; on average, these stacks are five times taller today than they were in 1940. Thus, in addition to the growth in atmospheric loadings of pollutants, the potential for wide geographic dispersion through long-range atmospheric transport has also increased significantly.

An important consideration in any discussion of acid rain and its precursor emissions is the question of future levels of pollution. There is a general consensus among environmental scientists that current emission rates, if perpetuated, will produce massive and widespread environmental damage in eastern North America, particularly in the northeastern United States and eastern Canada, large areas of which are very sensitive to acid rain. Any increase in emissions above present levels, therefore, will serve to make a disastrous situation even worse.

Thermal Power Plants

Of great concern to eastern Canada are the SO_x and NO_x emissions from U.S. thermal power plants in the upper Ohio Valley. The understandable desire of the United States to achieve energy independence will necessitate a large-scale conversion of oil-fired plants to coal combustion. These proposed conversions have raised fears that SO_x emissions into the North American atmosphere will increase significantly and that a substantial portion of those emissions ultimately will be deposited in Canada, primarily in the sensitive eastern Canadian provinces.

The Sub-committee does not oppose these conversions to coal. Indeed, we support the principle of energy independence for both the United States and Canada. We maintain, however, that these conversions can be made in a manner that is consistent with a desirable level of environmental protection.

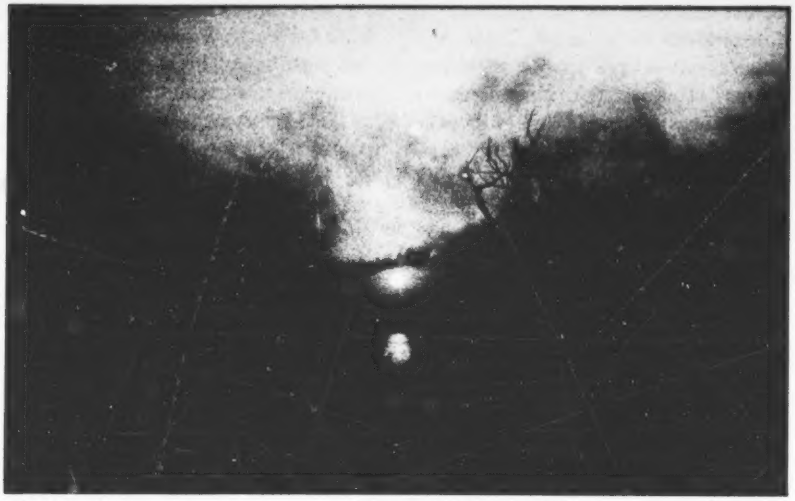
In February of this year, the U.S./Canada Work Group on Emissions, Costs and Engineering Assessment, working under the aegis of the 1980 Memorandum of Intent (M.O.I.) on Transboundary Air Pollution, provided projections for SO_x and NO_x emissions over the next two decades. The Work Group projected that SO_2 emissions from power plants in the United States will remain roughly constant; indeed, the M.O.I. Work Group suggests that emissions from this source may even decline somewhat.

The Sub-committee finds little comfort in these projections. First, the Work Group indicated that the "quantitative accuracies ... (of the computer models used to generate the projections) ... have considerable error margins." Also, the Work Group did not take into full consideration the potential SO_x emission increases associated with the massive oil-backout program in the United States which will substitute domestic coal resources for imported oil in many industries, including thermal power generating stations. The Sub-committee has received testimony from numerous witnesses that the U.S. coal conversions will indeed result in increased SO_x emissions.

Third, evidence presented by the Province of Ontario in its March 27, 1981 submission to the U.S. Environmental Protection Agency demonstrates that 20 U.S. thermal power plants are currently exceeding legal SO_2 emission standards by wide margins, some by factors of two or more. The 20 plants in question are located in Illinois, Indiana, Michigan, Ohio, Tennessee and West Virginia.

Not only are these plants producing SO_2 emissions generally well in excess of regulatory limits, they are proposing to the Environmental Protection Agency that their current SO_2 emission limits should be increased, from a total of 1.56 million tonnes per year to 2.82 million tonnes. This represents an 80 per cent increase. The *increase* in SO_2 emissions from these 20 power plants is approximately equal to one and one-half times the total annual SO_2 emissions from the giant INCO smelter in Copper Cliff, Ontario.

The Sub-committee deplores these proposals which have the effect of sacrificing North American environmental quality on the altar of indus-



The North American environment is severely threatened by actions such as the recent request by 20 U.S. power plants to allow SO_2 emission increases of up to 80%. These power plants currently exceed legal SO_2 emission standards, some by factors of two or more.

trial convenience. *The Sub-committee urges, in the strongest terms, that the United States Environmental Protection Agency disallow these appalling proposals and, moreover, that the EPA press for reduced SO_2 emissions from these same 20 thermal power plants.*

NO_x discharges from U.S. thermal power plants are projected to increase by about 50 per cent by the year 2000, from 5.6 million tonnes (1980) to about 8.4 million tonnes.

The M.O.I. Work Group's projections for SO_x emissions from Canadian thermal power plants also provide little comfort. Emissions are expected to increase from 0.7 million tonnes in 1980 to 1.3 million tonnes by 2000, if no emission controls are utilized. With appropriate controls, however, total SO_x emissions could decrease below 1980 levels.

At the present time, there are no flue gas desulphurization (FGD) scrubbers utilized by the electrical power industry in Canada in spite of the fact that this technology is available and has been shown to be effective in reducing SO_2 emissions from power plants in other countries. *The Sub-committee regards this situation as nothing less than disgraceful.*

Similarly, if NO_x emissions from Canada's thermal power plants are not controlled, total output will double from 0.3 million tonnes to 0.6 million over the next two decades.

The generation of electricity from conventional thermal power plants in Canada will have increased by about 50 per cent between 1977 and 1990. All of this increased thermal capacity will be fueled by coal as Canada seeks to reduce its consumption of, and dependence on, petroleum, which is a depleting and increasingly expensive resource.

The majority of thermal generator additions will be made in Alberta and British Columbia; both provinces are fortunate in possessing large resources of low-sulphur coal. Saskatchewan and Nova Scotia will also increase substantially their share of electricity generation from coal-fired units.

By 1989, Nova Scotia will have increased its proportion of electrical power generation from coal to 49.48 per cent from 10.40 per cent in 1977. Comparable figures for Saskatchewan are 55.72 per cent (1977) and 71.05 per cent (1989); for Alberta, 61.51 per cent (1977) and 81.94 per cent (1989); for British Columbia, 0 per cent (1977) and 7.28 per cent (1989).

New Brunswick will also come to rely more heavily on coal-fired units in the future, but the increase will be much smaller than for Nova Scotia. In 1977, coal accounted for 7.56 per cent of the electricity generation mix in New Brunswick and this will rise to 10.04 per cent in 1989 as some existing oil-fired stations are converted to coal. This relatively small increase is made possible by the construction of the Point Lepreau nuclear station which will account for 21.98 per cent of New Brunswick's electrical power by 1989.

Although Canada is, in relative terms, an energy-rich nation, this country has, in common with other industrialized nations, become dependent upon imports of expensive and strategically insecure foreign oil supplies. Currently, Canada imports some 253,000 barrels of oil a day on a net basis, 403,000 barrels a day in total. If no energy policy change is effected, increased oil use and dwindling supplies of domestic crude will combine to increase this importation to over 600,000 barrels a day by the mid-1980s.

The Federal Government's National Energy Program (NEP), announced in October 1980, proposes to reduce the use of oil in each of the residential, commercial and industrial sectors in every province to no more than 10 per cent of total energy used in those sectors. If this strategy were effected immediately, Canada's oil consumption would be reduced by 390,000 barrels a day.

Under the NEP, a Utility Off-Oil Fund will be established, with funding over the initial four years of $175 million, to finance, on a grant basis, up to 75 per cent of the cost of "environmentally acceptable" conversions of oil-fired electricity plants to coal.

This program is aimed primarily at Nova Scotia and New Brunswick, both of which rely heavily on imported oil for electricity generation and, as a consequence, have among the highest electricity rates in Canada. In 1977, Nova Scotia produced 58.64 per cent of its electricity from oil; the comparable figure for New Brunswick was 33.48 per cent.

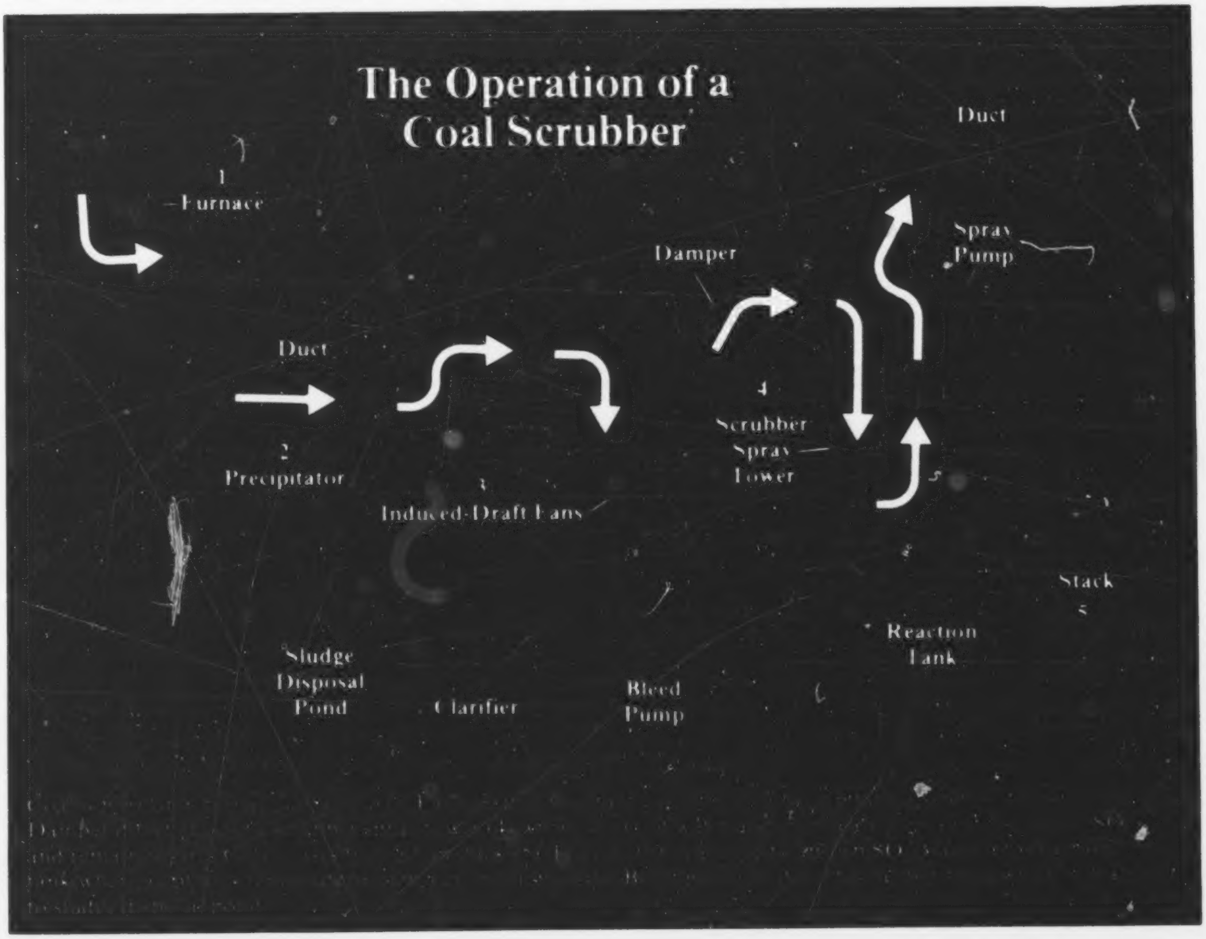
The Sub-committee fully supports the aims and objectives of the National Energy Program to reduce Canada's dependence on foreign oil supplies and at the same time to ease the strain on our international balance of payments.

Nonetheless, the Sub-committee is very concerned about the environmental consequences of the proposed coal conversions in eastern Canada, particularly since Nova Scotia and New Brunswick coals have a high sulphur content. The Sub-committee believes that the NEP's stipulation that coal conversions should be "environmentally acceptable" is dangerously imprecise.

The Sub-committee has received evidence that the oil-fired thermal power plant at Coleson Cove in New Brunswick is a candidate for conversion to coal, possibly with funding from the Federal Government under the National Energy Plan. At the present time, the Coleson Cove generating station is the largest point source of SO_2 in the Atlantic region, producing about 50,000 tonnes per year. Thermal coal used in New Brunswick has an extremely high sulphur content, ranging up to 8 per cent. This level is *15 to 20 times* higher than that in western Canadian coal.

The Sub-committee was informed at the Halifax public hearing that if Coleson Cove is converted to coal, there will possibly be a reduction in emissions because the generating capacity of the station will be reduced. This is encouraging news, but the issue of emission control devices and strategies still has to be confronted.

The Sub-committee believes strongly that acid rain-causing emissions from all sources in Canada must be systematically reduced. We reject the familiar argument that, until more information is developed to link specific emissions with specific downwind environmental effects, there should be no emission control programs implemented. The Sub-



The Operation of a Coal Scrubber

committee agrees with the view of the Canadian Nature Federation when they recommended at the Halifax public hearing that "the Federal and Provincial Governments should act speedily to install emission control technology without delay so that we will be in a better position to convince U.S. officials to do likewise and so that we will help protect our regional environment."

The Sub-committee is concerned that the environment ministries in Nova Scotia and New Brunswick are too readily inclined to accept the hypothesis that air pollutants emitted in the Atlantic region are harmlessly deposited in the ocean. We are not convinced that sufficient research has been done in this area to substantiate that claim. Nor are we satisfied that acid rain and its precursors do not have a significant effect on the ocean environment, particularly in near-shore areas. We believe that much more research needs to be carried out to clarify these points of concern.

Recommendation 1

The Sub-committee recommends that grants from the National Energy Program's Utility Off-Oil Fund for conversion of oil-fired electricity plants to coal be made conditional upon the installation of the best available emission control technology for oxides of sulphur and nitrogen.

The Sub-committee acknowledges the possibility that some coal conversions may be made independently, without direct financial assistance from the Federal Government. We believe, however, that the same criteria for environmental protection should apply as in situations involving Federal Government grants.

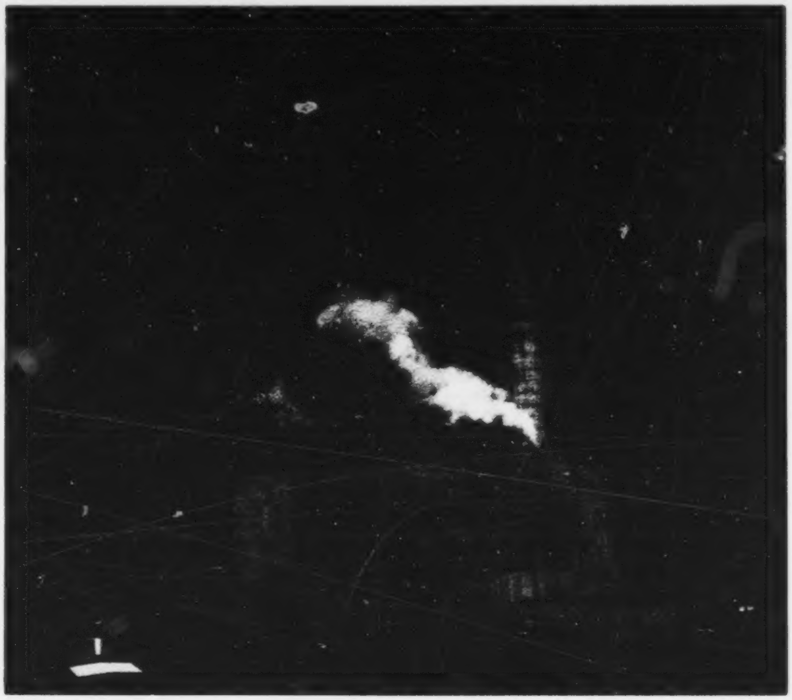
Recommendation 2

The Sub-committee recommends that all conversions of oil-fired electricity plants to coal in Canada, whether or not such conversions are financed in whole or in part by government funds, be carried out utilizing the best available emission control technology for oxides of sulphur and nitrogen.

Nova Scotia presently generates about one-third of its electrical power from coal; almost 40 per cent is now generated by burning expensive imported oil. The Nova Scotia Government has adopted a policy to develop the province's indigenous coal resources for electrical energy production while phasing out oil as an electricity source. We have already noted that Nova Scotia coal, unlike Western Canadian coals, has a high sulphur content which ranges between 1.5 and 5 per cent.

In 1980, the Nova Scotia Power Corporation's thermal generating stations emitted 115,000 tonnes of SO_2 and 25,500 tonnes of NO_x. By the year 2000, with conversion of oil-fired plants to coal and with the addition of new coal-fired plants at Lingan in Cape Breton, emissions of both pollutants could double. No emission control devices are currently planned or in place at coal-fired stations in Nova Scotia although the Lingan facility will have built-in capacity for wet scrubbers.

At the public hearings in Halifax, the Sub-committee heard testimony from numerous witnesses expressing great concern about acid rain-causing emissions from the existing and proposed coal-fired plants at the Nova Scotia Power Corporation's Lingan generating station. It is the Sub-committee's opinion that the uncontrolled release of pollutants from this establishment is unacceptable. *We believe that the best emission control technologies should be used at Lingan, particularly because of the high sulphur content of the coal used in this station and because the station's emissions have the potential of contributing to the acid rain problem in Newfoundland.*



The Coleson Cove generating station in New Brunswick is the largest point source of SO_2 in the Atlantic region, producing about 50,000 tonnes annually.

Recommendation 3

The Sub-committee recommends that the Lingan Generating Station operated by the Nova Scotia Power Corporation at Cape Breton be compelled to utilize the best available emission control technology for oxides of sulphur and nitrogen. This recommendation applies to generating units presently in operation and to those units planned or under construction.

It was noted earlier that all new thermal power plants proposed for construction in Canada over the next two decades will be coal-fired. This choice recognizes the fact that Canada's hydro potential is, in many regions, fully exploited and that oil and gas reserves are being depleted more rapidly than are coal reserves.

A number of proposed coal-fired power plants have been brought to the Sub-committee's attention during the course of our study of the acid rain problem. These include the 2,000 megawatt plant at Hat Creek, British Columbia, about 80 kilometres west of Kamloops. This plant will burn approximately 36,000 tonnes per day of low-grade thermal coal with a sulphur content of about 0.5 per cent. The Hat Creek plant will incorporate a flue-gas desulphurization (FGD) process that will reduce SO_2 emissions to about 150 tonnes per day at maximum load. Without the FGD scrubber, there is a potential for a daily emission rate of 360 tonnes of SO_2. Potential NO_x emissions have been estimated at 136 tonnes per day.

The Alberta electric utilities currently produce 3,002 megawatts of electricity from coal-fired power plants out of a total generating capacity of 5,218 megawatts. Coal will remain the major source of electric power in Alberta and, by 2005, an additional 7,875 megawatts of coal-sourced electrical power will be produced in that province.

Alberta's coal, like British Columbia's, is low-grade thermal coal with a sulphur content of about 0.4 per cent. Coal-fired power plants in Alberta produced about 73,200 tonnes of SO_2 in 1980; by 2005, this will have increased to about 312,000 tonnes. No emission control devices are planned for the Alberta thermal power plants, except for electrostatic precipitators to collect fly-ash.

Saskatchewan also relies heavily on coal for electric power generation. Saskatchewan coal is lignite with a sulphur content between 0.4 and 0.6 per cent. In 1980, thermal power stations produced 32,000 tonnes of SO_2, or 74 per cent of the province's total emissions, and about 37,000 tonnes of NO_x, equal to 26 per cent of the provincial total. In 1990, it is estimated that total SO_2 emissions will more than double to 66,600 tonnes (74 per cent of total) and NO_x emissions from coal-fired plants will rise to 82,000 tonnes (42 per cent of total). No SO_2 or NO_x emission control devices are planned for these new stations.

Ontario Hydro is the second largest emitter of acid rain-causing pollutants in Ontario. In 1981, it is estimated that the corporation will have produced between 560,000 and 609,000 tonnes of SO_2 and NO_x combined although recent reports have indicated that there is uncertainty about the actual amounts of SO_2 and NO_x that will be released in 1981 by Ontario Hydro. In 1980 the combined total was 475,000 tonnes.

Ontario Hydro uses coal-fired thermal generating stations to produce about one-quarter of the province's electricity. Overall, the coal-fired stations produce about 20 per cent of Ontario's acid rain-causing emissions. We noted earlier that Ontario Hydro does not currently utilize any FGD scrubbers in its thermal power plants.

On January 26, 1981, the Chairman of Ontario Hydro, Mr. Hugh Macauley, announced that the corporation was embarking on a course of action that would reduce total sulphur dioxide and NO_x emissions to 300,000 tonnes by 1990. This will produce an emission reduction of more than 40 per cent; during the same period electrical generation capacity will increase by 50 per cent.

The Ontario Hydro emission control program includes the installation of limestone slurry flue gas desulphurization units (scrubbers), either at the Lambton plant on the St. Clair River or at Nanticoke on Lake Erie. These two plants are the largest operated by Ontario Hydro.

The Sub-committee is both surprised and disappointed that Ontario Hydro made no reference to the two-unit 400 megawatt coal-fired station planned for Atikokan; this station is scheduled to come into operation in two phases, in 1984 and 1988. Similarly, there was no reference to special control measures for the two-unit 300 megawatt extension at Thunder Bay; these two units are scheduled to commence service in May and October 1981.

Environmentalists in Canada and the United States are particularly concerned about these coal-fired stations because of their close proximity to Minnesota's Boundary Waters Canoe Area, a million-acre wilderness area, and to Ontario's Quetico Provincial Park. Both of these areas are already under stress from acid rain and both lie in geological zones that are deficient in buffering capacity.

A number of witnesses who appeared before the Sub-committee supported a rigorous approach to emission controls on coal-fired power plants.

Mr. Martin Rivers of Environment Canada's Atmospheric Environment Service informed the Sub-committee that suitable technology is available to significantly decrease emissions from coal-fired electrical generating plants. He also indicated that, although capital investment and operating costs for flue gas desulphurization scrubbers appear to be high, the cost to the individual electricity consumer would be small: "... our own feeling is that ... a consumer would not even see the increased cost in generating electricity ... When one looks at the thermal power industry across Canada, they are Crown corporations (sic) and capital *per se* should not be of much concern because the thermal power industry does not have to worry about alternate investment opportunities ... it really means nothing to that particular industry."

The Sub-committee is aware that not all Canadian electrical utility companies are crown corporations; in Alberta, for example, some 84 per cent of the province's electricity is produced by Calgary Power Ltd. and Alberta Power Ltd., both of which are investor-owned. Nevertheless, the Sub-committee accepts the general tenor of Mr. Rivers' comments on this issue.

With specific reference to Ontario Hydro, Mr. Murray Gaunt, former Liberal Environment Critic in the Ontario Legislature, recommended to the Sub-committee that: "All existing and new coal-fired generating stations in Ontario should be made to comply with the point source removal of SO_2 based on best available technology and this should be accomplished immediately."

The Federation of Ontario Naturalists, appearing at the Sub-committee's Toronto hearing in October 1980, also made specific suggestions with reference to Ontario Hydro: "Install best available technology on all existing thermal generating facilities with priority given to the Nanticoke, Lakeview, and Lambton generating stations", and "Install abatement equipment on all new or converted thermal stations such that SO_2 emissions are reduced by at least 90 per cent of what they would be without abatement equipment for high sulphur coal, and by 70 per cent for low sulphur coal."

The Sub-committee has carefully considered all of the evidence it has received on coal-fired thermal power plants in the various regions of Canada. We are aware that there are regional differences in terms of geology, weather patterns, acidity of precipitation, and so on. Some witnesses from western Canada informed the Sub-committee that acid rain is not a problem in the west. Other witnesses from the same region, while agreeing with this view, argued that the best way to prevent an acid rain problem in the prairies and British Columbia is by reducing SO_x and NO_x emissions to the lowest practicable levels.

The Sub-committee concurs with the latter view and therefore makes the following recommendation with respect to coal-fired power plants.

Recommendation 4

The Sub-committee recommends that all new coal-fired electricity plants planned or under construction in Canada be compelled to utilize the best available emission control technology for oxides of sulphur and nitrogen.

The Sub-committee has accorded special attention to Ontario Hydro because of the importance of this industry in Canada's most populous and most heavily-industrialized province, and because Ontario is situated in, and borders on, geologically sensitive areas of North America. Further, emissions from Ontario can produce acid rain in downwind areas of Canada, including Quebec and the Atlantic region; there is also evidence that Ontario-sourced emissions are producing acid rain in parts of the United States.

The Sub-committee has studied the evidence supplied to it by Ontario Hydro and applauds the decision by the corporation to effect an emission reduction of more than 40 per cent by 1990. We believe, however, that even greater reductions in emissions are feasible and affordable.

Recommendation 5

The Sub-committee recommends that the Federal Government urge the Ontario Ministry of the Environment to compel Ontario Hydro to utilize the best available technology to control emissions of sulphur and nitrogen oxides at all existing and new coal-fired electrical generating stations in that province.

Non-Ferrous Smelters

The non-ferrous smelting industry is by far the largest source of sulphur dioxide in Canada. In 1980, the industry emitted about 2 million tonnes of SO_2, approximately 42 per cent of Canada's total SO_x emissions. Had the smelters been operating at full capacity, however, the total would have been 2.7 million tonnes. Another problem with the non-ferrous smelter industry is that most of the smelters are located east of the Manitoba-Saskatchewan border; thus, their SO_2 emissions, in the form of acid rain, are capable of impacting on the most sensitive geological regions of Canada, including Saskatchewan, Ontario, Quebec and the Atlantic region.

Among the individual smelting operations in Canada, the INCO Limited nickel smelter at Copper Cliff, Ontario is the largest point source of SO_2 in Canada, emitting 2,270 tonnes per day. INCO's 381 metre (1,240 foot) "superstack" at Copper Cliff, which disperses the SO_2 emissions high into the atmosphere, has almost become a symbol for acid rain and the long-range transport of pollutants.

The Noranda Mines copper smelter at Noranda, Quebec emits 1,570 tonnes of SO_2 per day, and is the second largest emitter in the non-ferrous smelter sector; following

Noranda are the INCO nickel smelter at Thompson, Manitoba (1,130 tonnes per day), the copper-zinc smelter operated by Hudson Bay Mining and Smelting Company Limited at Flin Flon, Manitoba (800 tonnes per day), the Falconbridge Nickel Mines Limited smelter at Sudbury, Ontario (420 tonnes per day) and the Noranda copper smelter at Murdochville, Quebec at 230 tonnes per day.

There are other smelters operating in eastern Canada, including two zinc smelters, at Valleyfield, Quebec and Timmins, Ontario, and a lead smelter at Belledune, New Brunswick. These smelters are presently controlling 85 to 90 per cent of the sulphur in their ores and are not, therefore, considered to be major emitters of SO_2.

To be fair to the Canadian smelting industry, some operations have in fact reduced their SO_2 emissions significantly over the past decade. The INCO smelter at Copper Cliff reduced its SO_2 emissions from about 5,500 tonnes per day in 1969 to 3,300 tonnes per day by 1978. The current emission level of 2,270 tonnes per day is the maximum permitted under Ontario legislation but has been achieved by a cutback in production at the smelter rather than through improved emission control technology. The Ontario Control Order specifies that INCO must further reduce emissions to 1,770 tonnes per day after December 31, 1982. The INCO smelter is presently successful in containing about 70 per cent of the sulphur in the ore processed by the smelter.

The Falconbridge nickel smelter emitted about 940 tonnes per day of SO_2 in 1969; today, the daily emission level stands at about 420 tonnes. This is a 55 per cent reduction in emissions over about a ten-year period. Falconbridge's emission control system contains about 80 per cent of the sulphur in the ore.

Some large smelters have no emission control technology in place whatever. Included in this group are the Hudson Bay Mining and Smelting Company operation in Flin Flon, the INCO smelter in Thompson, and the Noranda copper smelter in Noranda, Quebec.

INCO's "superstack" at Copper Cliff, Ontario has become a symbol of the long-range transport of acid rain-causing pollutants.

The major SO_2 control methodologies available for non-ferrous smelters include sulphuric acid plants and liquid SO_2 production facilities. These methods are, however, dependent for success on relatively high concentrations of SO_2 — at least 4 per cent — in the smelter off-gas stream. Problems in SO_2 control arise when the concentration of the pollutant in the off-gas stream is below the 4 per cent level. The INCO smelter at Copper Cliff uses both a sulphuric acid plant and a liquid SO_2 process to control emissions. Falconbridge and the Noranda smelter at Murdochville use sulphuric acid plants for containment of SO_2.

Where the smelter off-gas streams contain too low a concentration of SO_2 for sulphuric acid production, the matter of effective emission control is more difficult. One approach is to utilize flue gas desulphurization scrubbers, a technology similar in principle to that used on coal-fired power plants. Two flue gas scrubbers are currently in operation at Canadian smelters; the Cominco Limited lead-zinc smelter at Trail, B.C. utilizes an ammonia scrubber and the Afton Mines Limited copper smelter near Kamloops, B.C. uses a dual alkali scrubber. Other approaches to solving weak off-gas streams include upgrading roaster and reverberatory furnace operations to produce a stronger SO_2 gas stream for utilization in an acid plant. Another approach is to devise alternative smelter process technology to generate strong SO_2 gas streams, or to eliminate SO_2 formation in those parts of the process which produce only weak gas

Table 8: Non-Ferrous Smelter Industry, Eastern Canada*, 1981

Smelter	Location	Product	SO_2 Emission Rates	Sulphur Containment Process
Hudson Bay Mining and Smelting Co. Limited	Flin Flon, Manitoba	Copper, Zinc	Current Manitoba control order 800 tonnes per day average monthly mean	None
INCO Limited	Thompson, Manitoba	Nickel	Current Manitoba control order 1130 tonnes per day	None
INCO Limited	Copper Cliff, Ontario	Nickel, Copper	Current legislation limits emissions to 2250 tonnes per day	1. Liquid Sulphur Dioxide 2. Sulphuric Acid Plant
Falconbridge Nickel Mines Limited	Sudbury, Ontario	Nickel, Copper	[illegible] tonnes per day under current control order	Sulphuric Acid Plant
Noranda Mines Limited, Horne Division	Noranda, Quebec	Copper	[illegible] tonnes per day	None
Noranda Mines Limited, Mines Gaspé	[illegible], Quebec	Copper	[illegible]	Sulphuric Acid Plant

[illegible]

streams.

The Sub-committee has received evidence that development of specific SO_2 emission control technology appropriate for non-ferrous smelters must consider the unique nature of each individual smelter. Each smelter is specifically designed to process a particular ore concentrate and utilizes a specific metallurgy to successfully treat that concentrate.

It is not, therefore, possible for the Sub-committee to make specific recommendations for appropriate SO_2 emission control technologies for use in non-ferrous smelting operations.

The Sub-committee fully appreciates the difficulties and costs involved in this field. We have received evidence, for example, that Falconbridge Nickel Mines Limited spent some $75 million between 1965 and 1972 in an unsuccessful effort to develop an improved production process that would have significantly reduced SO_2 emissions. Falconbridge eventually achieved a 55 per cent reduction of SO_2 emissions through construction of a new smelter and a sulphuric acid plant; the total cost of this project was $85 million.

Nevertheless, the Sub-committee is resolute in its belief that SO_2 emissions from the non-ferrous smelting industry have to be significantly reduced below current levels. Emission reductions are most urgently required in those smelters where no SO_2 containment technology is currently utilized. The Sub-committee has received testimony from the owners of these smelters purporting to demonstrate that current SO_2 emissions are having no measurable impact on the Canadian environment. The Sub-committee does not accept these arguments.

Similarly, the Sub-committee believes that SO_2 emissions from the INCO and Falconbridge smelters must be progressively reduced below current levels. The Sub-committee commends the efforts of INCO and Falconbridge for their past emission reduction programs and urges both companies to effect continued reductions in the future.

The Sub-committee has studied with great interest the SO_2 emission reduction program put in place at the Cominco Limited lead-zinc smelter at Trail, British Columbia. This smelter is of particular interest because of its historical relevance to the transboundary pollution question.

The Cominco Limited operation

at Trail began in 1894 with the construction of an open-pit roaster to smelt copper-gold ore mined in Rossland, B.C. A lead smelter was added to the site in 1901 and a zinc plant was started up in 1916. By 1916, SO_2 emissions from the smelting operations at Trail had increased to 308 tonnes per day. The first 122 metre (400 ft.) stack was built in 1925, by which time emissions had increased to 363 tonnes per day.

The tall stack transferred the pollution problem from Trail to the State of Washington and this resulted in complaints from residents in the affected areas about damage to vegetation and property. In 1926, when emissions had increased to 544 tonnes of SO_2 per day, the first claim for smoke damage was filed against the company by a fruit farmer in Northport, Washington.

The company built a second 122 metre stack in 1927; in that year, the United States Government intervened in the legal proceedings on smoke damage caused by the smelter. The issue was then referred to the International Joint Commission (IJC) for consideration. In 1931, the IJC made recommendations for financial settlement of damage claims and for a method of future claims settlement. These recommendations were not satisfactory to the two governments.

The lead and zinc operations at Trail had continued to expand but in 1930 the company had commenced operation of three full-scale sulphuric acid plants in combination with fertilizer plants to consume the by-product acid. As a result of these new processes, SO_2 emissions fell to 435 tonnes per day, a reduction of 20 per cent. By 1934, however, emissions of SO_2 had increased again to 635 tonnes per day on average.

In 1936, an elemental sulphur plant started production and an ammonia scrubber was added to the complex to remove SO_2 from weak gas streams that could not be used in the sulphuric acid plants. These two processes reduced emissions of SO_2 to 272 tonnes per day.

Consideration of the transboundary legal aspects of the Trail smelter situation progressed in parallel with the technological innovations installed at the smelter complex. In 1935, Canada and the United States signed an agreement under which Canada would pay the amount of damages declared by the IJC to be owing to the United States. In addition, the Trail Smelter Arbitral Tribunal was established. The Tribunal was a three-person judicial body empowered to determine the nature of damages caused and reparations owed to the United States after January 1932.

In 1938, the company started up two more full-scale sulphuric acid plants and SO_2 emission levels again dropped, this time to 254 tonnes per day. The Trail Smelter Tribunal rendered its final decision in 1941 and imposed a complex control regime for the smelter operation. That control regime remains in force today.

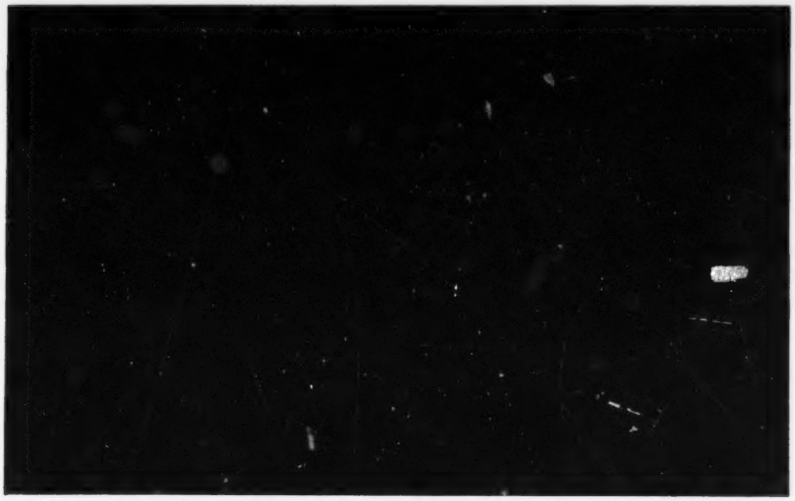
By 1943, with the installation of ammonia scrubbing of the sulphuric acid plant tail gases, SO_2 emission levels were down to 109 tonnes per day. Process improvements continued at Trail and, by 1954, emissions had fallen to 54 tonnes per day. Since 1954, metal production has continued to increase at the Trail Smelter but SO_2 emission levels have remained substantially the same.

In summary, in 1906, the Cominco Limited smelter operation at Trail emitted 91 per cent of the sulphur being treated. By 1954, the situation had been reversed, with 93 per cent of the sulphur being retained and only 7 per cent being released into the atmosphere. The 93 per cent containment level has continued up to the present although the tonnage of sulphur being treated has increased.

The Sub-committee is favourably impressed with the success of the sulphur containment program at the Cominco Limited smelter. Further, we believe that this operation can serve as a constructive example for the non-ferrous smelter industry in general.

The Sub-committee has also received evidence that other smelters in Canada are successful in containing 85-90 per cent of sulphur treated. This group includes the Texasgulf zinc smelter at Timmins, Ontario, the CEZ zinc smelter at

The copper and zinc smelter operated by Hudson Bay Mining and Smelting at Flin Flon, Manitoba emits a total of 800 tonnes of SO_2 daily.



The Cominco smelter at Trail, British Columbia has achieved notable success with its SO_2 emission control program.

Valleyfield, Quebec, and the Brunswick Mining and Smelting Corporation Limited lead smelter at Belledune, New Brunswick.

The Sub-committee has deliberated at length over the difficulties faced by the non-ferrous smelting industry in reducing SO_2 emissions. *However, our overriding concern must rest with the protection of the environment and all other considerations, however important, must remain subsidiary to that basic goal. We are satisfied that the technology is available today to dramatically reduce SO_2 emissions from the non-ferrous smelting industry.* The Sub-committee suggests that a reasonable goal for the Canadian non-ferrous smelter industry is the containment of approximately 80 per cent of the sulphur in smelter feed. We believe the technology is available to achieve this level of containment.

The INCO Limited smelter at Copper Cliff, Ontario is the largest point source for SO_2 in Canada. The Sub-committee has acknowledged the fact that INCO has effected significant control of SO_2 emissions over the past decade and now is containing approximately 70 per cent of the sulphur in the ore. We are also aware that INCO was able to meet current regulatory limits on SO_2 emissions only by reducing production at the smelter.

The Sub-committee has reviewed evidence attesting to the fact that the Copper Cliff smelter is an old facility and that extensive modifications are needed to effect major reductions in SO_2 emissions. We do not underestimate the difficulties and costs involved in a redesign and rebuilding program.

The Sub-committee reviewed several estimates of the costs involved in reducing SO_2 emissions from the INCO smelter and these are discussed in a later section of the report. One estimate, formulated by Brian Felske and Associates, is for a reduction of emissions to 1,360 tonnes of SO_2 per day. In 1980 dollars, the capital cost of needed renovations was estimated to be $325 million. Assuming that the by-product sulphuric acid could be sold, rather than neutralized, the annual costs to INCO in this scenario would be $40.57 million, or $58.35 per tonne of contained sulphur. With appropriate tax incentives, INCO's annual costs would drop to $18.02 million, or $25.92 per tonne of sulphur contained.

Environment Canada estimated that the cost to INCO of reducing SO_2 emissions to 900 tonnes per day would be $430 million in capital costs, plus annual operating costs of $60.1 million; this latter figure translates into $90.72 per tonne of contained sulphur, again assuming that the by-product sulphuric acid could be sold. At higher levels of SO_2 containment, the cost per tonne of contained sulphur would increase to more than $100.

The cost per tonne of contained sulphur is significantly lower for the non-ferrous smelter industry than for coal-fired power plants. In the latter case, the estimated costs range from $485 per tonne for high-sulphur coal to $1,962 per tonne for low-sulphur coal, if limestone scrubbing is the abatement technology used.

In 1980, INCO's net income after taxes was $219 million, an indication of the company's profitability (Appendix III). The ore bodies in the Sudbury area are both extensive and of high quality. The Sub-committee believes, therefore, that INCO can afford to make the necessary modifications to its Copper Cliff smelter to achieve an SO_2 emission level of 750 tonnes per day.

Recommendation 6

The Sub-committee recommends that the INCO Limited smelter at Copper Cliff, Ontario be compelled to reduce its sulphur dioxide emissions to 750 tonnes per day and that this level be attained within five years.

The INCO Limited smelter at Thompson, Manitoba currently emits 1,130 tonnes of sulphur dioxide per day. The smelter has no emission control devices in place at the present time. In theory, this smelter operates under a control order from the Manitoba Government. It seems clear, however, that this "control order" merely accords formal sanction to uncontrolled atmospheric pollution. This situation, and the curious philosophy that supports it, is totally unacceptable to the Sub-committee.

The Sub-committee is satisfied that the INCO Limited smelter at Thompson, Manitoba can reduce its emissions of sulphur dioxide to an amount equivalent to 20 per cent of the sulphur in the smelter feed. We suggest that a substantial portion of the SO_2 can be contained through construction of a sulphuric acid plant and that major modifications in other parts of the smelter can effect additional reductions to achieve the 20 per cent level.

Recommendation 7

The Sub-committee recommends that the INCO Limited smelter at Thompson, Manitoba be compelled to reduce its sulphur dioxide emissions to 220 tonnes per day and that this level be attained within five years.

The Falconbridge Nickel Mines Limited smelter at Sudbury, Ontario has effected greatly improved sulphur dioxide containment in recent years. Information presented by the company to the Sub-committee indicates that about 80 per cent of the sulphur in the ore processed by Falconbridge is successfully contained. The Sub-committee is persuaded that this containment level can be increased to 90 per cent utilizing technology currently available to the smelting industry. This level of containment mandates a 50 per cent reduction in current emissions from the Falconbridge smelter.

Recommendation 8

The Sub-committee recommends that the Falconbridge Nickel Mines Limited smelter at Sudbury, Ontario be compelled to reduce its sulphur dioxide emissions to 210 tonnes per day and that this level be attained within five years.

The Noranda Mines Limited (Mines Gaspé) smelter at Murdochville, Quebec currently emits an average of 230 tonnes of sulphur dioxide per day. Emissions from the smelter are controlled at present by a sulphuric acid plant. The Sub-committee believes that the technology is available to achieve an 80 per cent containment of sulphur in the smelter feed at the Murdochville smelter. Containment at this level would result in an approximate 50 per cent reduction in SO_2 emissions from the smelter.

Recommendation 9

The Sub-committee recommends that the Noranda Mines Limited (Mines Gaspé) smelter at Murdochville, Quebec be compelled to reduce its sulphur dioxide emissions to 115 tonnes per day and that this level be attained within five years.

The Hudson Bay Mining and Smelting Company Limited smelter at Flin Flon, Manitoba and the Noranda Mines Limited (Horne Division) smelter at Noranda, Quebec are economically marginal operations. The Sub-committee recognizes that, if these smelters are required to meet an 80 per cent containment of sulphur in smelter feed without some form of economic assistance, these smelters may be forced to terminate their operations. This eventuality would have severe consequences for the communities of Flin Flon and Noranda.

Table 9: Summary of Sub-committee's Recommendations for the Canadian Non-Ferrous Smelter Industry

Smelter	Location	Current SO_2 Emission Rates	Recommended SO_2 Emission Rates
INCO Limited	Copper Cliff, Ontario	2,270 tonnes/day	750 tonnes/day
INCO Limited	Thompson, Manitoba	1,130 tonnes/day	220 tonnes/day
Falconbridge Nickel Mines Limited	Sudbury, Ontario	420 tonnes/day	210 tonnes/day
Noranda Mines Limited (Mines Gaspé)	Murdochville, Quebec	230 tonnes/day	115 tonnes/day
Noranda Mines Limited (Horne Division)	Noranda, Quebec	1,570 tonnes/day	312 tonnes/day
Hudson Bay Mining and Smelting Company Limited	Flin Flon, Manitoba	800 tonnes/day	160 tonnes/day
	Total	6,420 tonnes/day	1,767 tonnes/day

It is neither the intention nor the desire of the Sub-committee to inflict severe hardship on such individual Canadian communities. This is a particularly important consideration in the acid rain issue because, as we have noted, the acid rain-causing emissions are often transported over long distances and the sulphuric and nitric acids are deposited far away from the original sources. The corollary of this observation is that abatement of emissions at source will primarily benefit Canadians in distant communities. It is the Sub-committee's opinion, therefore, that the control of domestic sources of acid rain precursors must be a countrywide undertaking and the costs, wherever necessary, must be shared by all Canadians.

Recommendation 10

The Sub-committee recommends that the Federal Government, in full consultation with concerned Provincial Governments and industry officials, convene a Task Force to study appropriate technologies and economic initiatives to implement an 80 per cent sulphur containment objective at the non-ferrous smelters operated by Noranda Mines Limited (Horne Division) at Noranda, Quebec and by Hudson Bay Mining and Smelting Company Limited at Flin Flon, Manitoba. The Task Force should be convened immediately and should report within a six-month period.

On August 29, 1980, the Canada-Ontario Task Force was convened to study improved sulphur dioxide emission control at smelters in the Sudbury basin. The Task Force is scheduled to deliver its final report on September 30, 1981. The Sub-committee trusts that the Task Force's document will embody the same resolve toward environmental protection displayed by our own report.

The Transportation Sector

The transportation sector will remain a relatively minor source of SO$_x$ over the next two decades; the United States and Canada combined will produce an estimated 1.0 million tons by the year 2000, the same amount estimated for 1980.

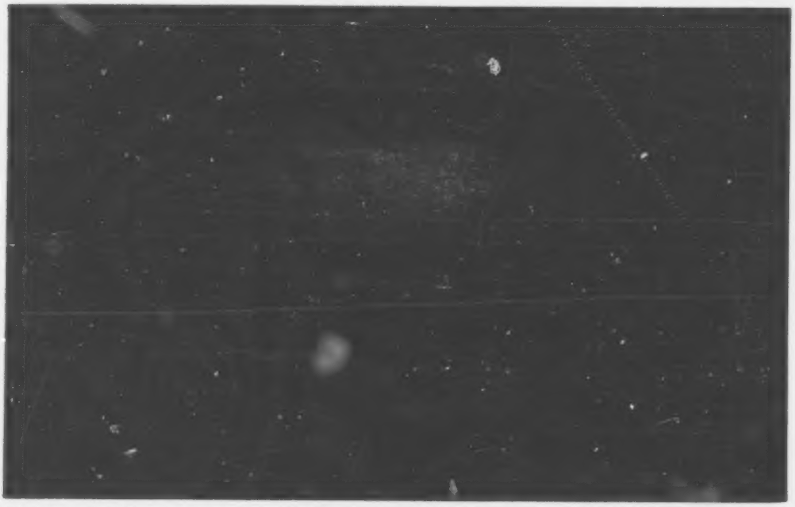
However, emissions of NO$_x$ from this sector are a major concern in both the United States and Canada, particularly in large urban centres. The problem with NO$_x$ generated in cities is two-fold: because the emissions from vehicles are near ground level, there are both short-range and long-range effects.

The short-range effects include formation of photochemical oxidants, producing smog, when NO$_x$ reacts with hydrocarbons in the presence of sunlight. Smog has a number of well-documented health effects including lung irritation and the aggravation of asthma and other respiratory diseases. NO$_x$, itself, is believed to have potentially serious health effects, particularly in connection with respiratory diseases.

There are two important long-range effects of oxides of nitrogen. Of primary concern to the Sub-committee is the formation of nitric acid from NO$_x$ through atmospheric chemical transformation. While it is not known what portion of NO$_x$ emitted by the transportation sector is transformed into acid rain, the contribution generally is held to be significant.

The second long-range effect of NO$_x$ is the formation of ozone. Ozone, like nitric acid, is a secondary pollutant in that it is not directly emitted into the atmosphere but is formed in the atmosphere in the presence of sunlight following complex chemical transformations of nitrogen dioxide (NO$_2$) and various reactive hydrocarbons. Ozone is the principal component of photochemical smog and a major cause of injury to plant foliage. Many important crop species in North America are subject to damage from ozone, including tobacco, beans, potatoes and cucumber.

In the United States, vehicle-sourced NO$_x$ emissions are expected to remain fairly stable over the next 20 years, rising to about 9.3 million tonnes from the 1980 level of 8.2 million tonnes. This will result from the growing numbers of smaller and more fuel-efficient cars to be pur-



This large urban centre is covered with a thick photochemical smog. The effect of this smog has proven to be potentially serious to human health and a major cause of injury to plant foliage.

Motor vehicles in Canada are known to emit three times more NO_x per vehicle mile than vehicles in the United States.

chased in the United States over this period.

In Canada, however, NO_x emissions from the transportation sector could increase from 1.0 million tonnes in 1980 to 1.6 million tonnes in 2000, if no further control action is taken in this country. If more stringent new-vehicle emission standards are adopted in 1985, however, NO_x emissions in Canada in 1990 could decrease 20 per cent from 1980 levels.

The Sub-committee has noted that the present Canadian new-vehicle emission standard for NO_x is 3.1 grams per vehicle mile (gpm) compared to the U.S. standard of 1.0 gpm for 1981 model passenger automobiles. *The Sub-committee is appalled that motor vehicles in Canada emit three times as much NO_x per vehicle mile as vehicles in the United States.*

The Sub-committee has also noted that the transportation sector produces about 50 per cent of the NO_x emissions in Canada. Although it is not known with certainty what portion of these emissions actually contribute to our acid rain problem, we are aware that oxides of nitrogen are a serious air pollution problem in our major cities; testimony to that effect was given to the Sub-committee by Mr. Walter Brabant of the Air Purification Division of the Montreal Urban Community. Also, several other witnesses before the Sub-committee noted that Canada's new-vehicle NO_x emission standards are significantly less stringent than those in the United States.

The Sub-committee is aware that emission control devices for automobiles are expensive and that their use might increase automobile fuel consumption. Nevertheless, we believe that enhanced protection of the North American environment justifies the additional costs involved.

Recommendation 11

The Sub-committee recommends that NO_x emission control standards for new motor vehicles sold in Canada be made at least as stringent as those enforced in the United States by the Environmental Protection Agency as of June 1981.

The Sub-committee received evidence from a number of witnesses concerning the appropriate Federal Government department which should have responsibility for the regulation of motor vehicle emissions. At the present time, this regulatory authority resides with the Ministry of Transport and emissions are controlled under the Motor Vehicle Safety Act.

The Sub-committee is satisfied that emissions from motor vehicles, including NO_x emissions, are much more effectively controlled in the United States than in Canada. We believe that this is due primarily to the fact that jurisdiction over motor vehicle emissions in the United States resides with the Environmental Protection Agency instead of with the Department of Transportation.

The Montreal-based environmental group, STOP, suggested to the Sub-committee that...

> *...the Government of Canada transfer legislative authority to regulate motor vehicle emissions from Transport Canada under the Motor Vehicle Safety Act to Environment Canada under the Clean Air Act, which already has significant responsibilities in this area.*

The Sub-committee concurs with this suggestion and we make the following recommendation.

Recommendation 12

The Sub-committee recommends that legislative authority to regulate motor vehicle emissions through standards applicable to manufacturers and distributors be transferred from the *Motor Vehicle Safety Act* to the *Clean Air Act* and hence from the Ministry of Transport to the Department of Environment which already has significant responsibilities in the area of air pollution.

TERRESTRIAL EFFECTS: AGRICULTURE AND FORESTRY

The effects of acid rain on agriculture and forestry are important considerations and many witnesses who appeared before the Sub-committee expressed their concern about these aspects of the problem. We are aware, however, that these are complex and difficult areas in which to carry out definitive research and that it will be some time before the necessary data have been assembled and appropriate conclusions drawn from the many studies currently underway and planned for the future.

The Sub-committee has reviewed evidence on all aspects of terrestrial effects of acid rain and also of the precursor pollutants, the oxides of sulphur and nitrogen. Other sulphur compounds, particularly sulphates, also may have effects on agriculture and forestry. Similarly, the Sub-committee is concerned about the effects of ozone, a secondary pollutant like acid rain which is also subject to long-range transport through the atmosphere. Although ozone is a distinct chemical entity, its source is closely related to that of acid rain. Ozone is not emitted directly into the atmosphere but is formed in the presence of sunlight as a consequence of chemical reactions involving nitrogen dioxide and various reactive hydrocarbons.

Ozone is recognized as a major component of photochemical smog and exerts important direct toxic effects on plant foliage. When plants are exposed to atmospheric ozone, visible foliar injury occurs: this may occur as lesions, bleaching of leaves, killing of parts of the leaf tissue (topical necrosis), or general chlorosis of leaf tissue (loss of chlorophyll).

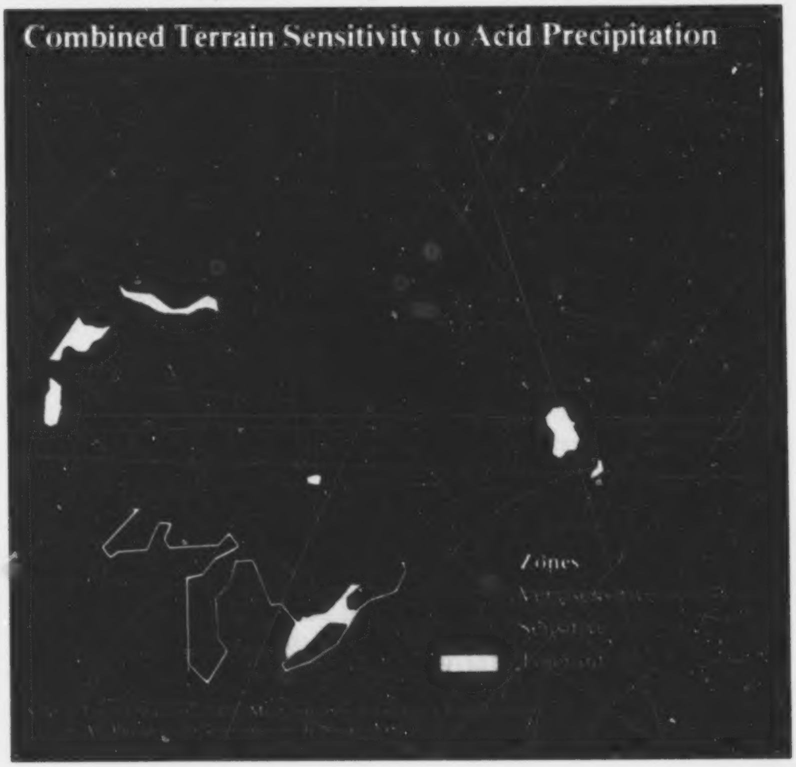
Ozone injury to plants has been extensively documented for many crop species in North America. Tobacco, beans, potatoes, grapes, onions, cucumber, celery, pumpkin, squash, and radish are included in this group. Effects on plants may include a reduction in plant weight leading to losses in yield as high as 10 per cent.

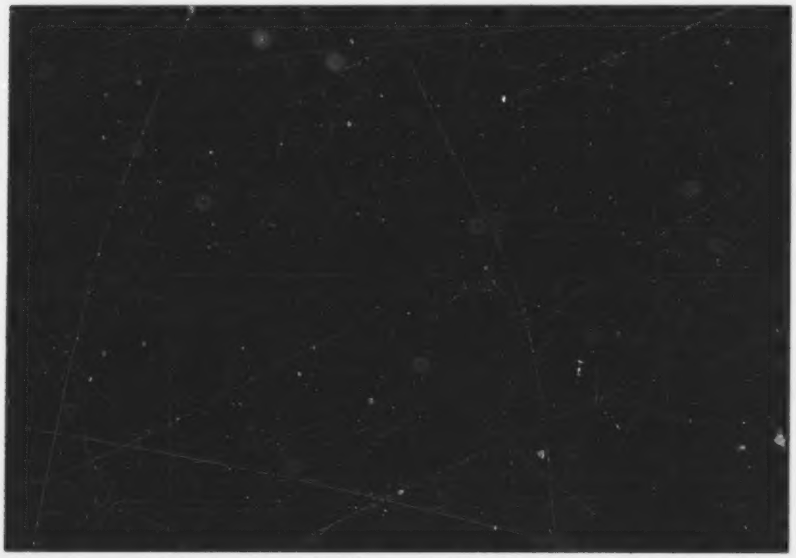
Acid rain also may have direct effects on plants, the most common being injury to the foliage together with certain physiological and morphological disturbances. It has been postulated that a decreased rate of growth of the plant may be the major consequence although direct evidence from field studies is not currently available.

Acid rain may also cause damage to protective structures on the plant surface, such as the leaf cuticle; interference with normal plant metabolism and growth processes; poisoning of plant cells by acidic substances; interference with plant reproduction processes; and synergistic interactions with other environmental stress factors. Included in this last group are increased susceptibility to pathogen and insect attack, and increased sensitivity to other environmental pollutants.

In controlled experiments using simulated acid rain, a variety of effects on plants has been recorded; these have included foliar injury and decreased yield although some species showed increased yields when exposed to precipitation in mid-pH ranges. This positive response is probably due to the nitrate-nitrogen in acid precipitation; nitrogen is an essential plant nutrient.

An important consideration for Canadian forests subjected to long-term acid rain loading is the cumulative effect of increased acidity on soils. The evidence currently available is, again, largely indirect but is sufficient to arouse concern that acid rain is increasing the acidity of forest soils and causing an accelerated drainage loss of useful nutrients. At the same time, potentially toxic elements are brought into solution at an increased rate. Of particular concern is the increased availability of aluminum which has been shown to be toxic to some valuable forest species. The overall result of soil acidification is a decreased


Combined Terrain Sensitivity to Acid Precipitation



The sugar maple leaf on the right illustrates the directly toxic effect of ozone on plants. Intensive research programs must be initiated and developed to determine all of the detrimental effects of acid rain on Canada's forests and agricultural crops.

potential of the ecosystem to support a healthy forest. Soil acidification is important in Canadian forests because these soils are already acidic and are thus especially sensitive to increased acidification.

The Sub-committee recognizes that the data base has to be substantially increased before firm conclusions can be reached about the effect acid rain is having, or may have, on Canadian forests. Nevertheless, we agree with the observation of Mr. Peter Rennie of the Canadian Forestry Service that "it is not...(appropriate that)...a patient should die before being considered ill" and that it is essential to abate acid rain in the interests of preserving the forest resource. We also agree that an intensive research effort must be continued to determine the precise effects of acid rain on the forest sector.

In this latter regard, the Sub-committee acknowledges the observation of Professor Paul L. Aird of the University of Toronto that... "The Canadian Forestry Service has been cut back by the Canadian government by 50 per cent in the last 10 years, and they are going to have to embrace a whole multitude of new problems that are just not being properly addressed."

Recommendation 13

The Sub-committee recommends that Environment Canada continue an intensive research program into the effects that acid rain is having on Canadian forests. The Sub-committee further recommends that the Federal Government conduct a thorough review of the structure and funding of the Canadian Forestry Service to determine if there is a need for increases in funding and/or person-years to effectively deal with the research requirements necessitated by the acid rain problem.

The Sub-committee cannot emphasize too strongly the importance of the Canadian forest resource in the context of our concerns about acid rain. Almost every Canadian province, from British Columbia in the west to Newfoundland in the east, relies on its forest resource for jobs and revenue. Overall, as we have noted, the forest industry in Canada is a $20 billion enterprise and a million Canadians depend on the industry, directly or indirectly, for employment.

Neither must we forget the value of Canadian forests as an integral part of this country's total ecosystem. If the forests are damaged, the myriad lakes and river systems will also suffer damage and the safety of our multitudinous and diverse wildlife populations will be compromised, perhaps irretrievably.

The safety of the forests is every Canadian's concern. But it is clear that the responsibility for protection of the forests must lie with those institutions who derive direct revenues from this resource. The forest industry has an immense investment in this resource equal to, if not greater than, that of the Federal and Provincial Governments. *The Sub-committee urges, in the strongest terms, that private industry and the Federal and Provincial Governments establish the closest possible liaison to develop research priorities and programs to protect Canada's forests from the threat of acid rain.*

The Sub-committee has received evidence that there have not been recorded any field observations of detrimental effects from acid rain on agricultural crops in Canada. However, we believe that a cautious approach to this situation is warranted by the vital importance of the agricultural resource to the country's well-being. The increased acidity of rainfall in combination with certain fertilization practices has rendered many Canadian soils sensitive to additional acid loadings. This has resulted in direct costs to farmers who have to apply increased amounts of lime to their fields.

The Sub-committee received evidence in Calgary from Dr. Martha Kostuch of Alberta's Public Advisory Committee on the Environment that there is a significant incidence

In Alberta the presence of sulphur dioxide in the atmosphere has been associated with selenium deficiencies which can cause severe physiological disease in cattle.

of "white muscle disease" in cattle in Alberta. This disease is a physiological disorder caused by a deficiency, or unavailability, of selenium in the animals' diet. There is evidence that the disease is caused, or exacerbated by, the ingestion of vegetation enriched with sulphur. Alberta has the second highest sulphur emissions in western Canada. Although this particular disease is not a result of acid rain *per se*, its existence and seriousness underscore the need to reduce emissions of sulphur dioxide into the atmosphere.

The Sub-committee was surprised and rather dismayed to learn that Agriculture Canada has not developed a specific research and monitoring program to study the effects of acid rain on soils and crops in Canada. Dr. S.S. Singh of Agriculture Canada informed the Sub-committee that the "acid rain problem has not come up that strong(ly) in our department." *Considering the importance of agriculture to Canada and in view of the many potential damaging effects of acid rain on crops and soils, the Sub-committee is persuaded that there is a need to develop a comprehensive research program into the effects of acid rain on crops and soils.*

Recommendation 14

The Sub-committee recommends that Agriculture Canada develop a comprehensive research program to study the effects of acid rain on crops and soils in Canada. This research program should include studies of the effects of acid rain precursors and ozone on crops and particular attention should be given to the effects that current fertilization practices are having on soils to render them more sensitive to cumulative acid loadings.

AQUATIC EFFECTS AND LIMING

Areas which are susceptible to damage from acid rain are characterized by a very low buffering capacity in the soils and rocks. Buffering capacity is present in certain types of rocks and soils, particularly those containing large quantities of carbonate-rich material such as limestone. If the soils and rocks have little buffering capacity, as occurs in the Precambrian Shield areas of Canada and parts of northern New York state, acid loading will eventually strip away the buffering capacity and runoff water entering lakes and streams will directly reflect the acidity of the rainfall.

Water bodies also may have a buffering capacity; the correct term is "alkalinity" and this provides a measure of the water's potential for neutralizing acid input. The greater the alkalinity of the water, the higher its pH value, and the greater the capacity of that water to neutralize acid precipitation. As would be expected, lakes and streams in areas with carbonate-rich soils have high alkalinities and, consequently, a pH value of 7.0 or higher.

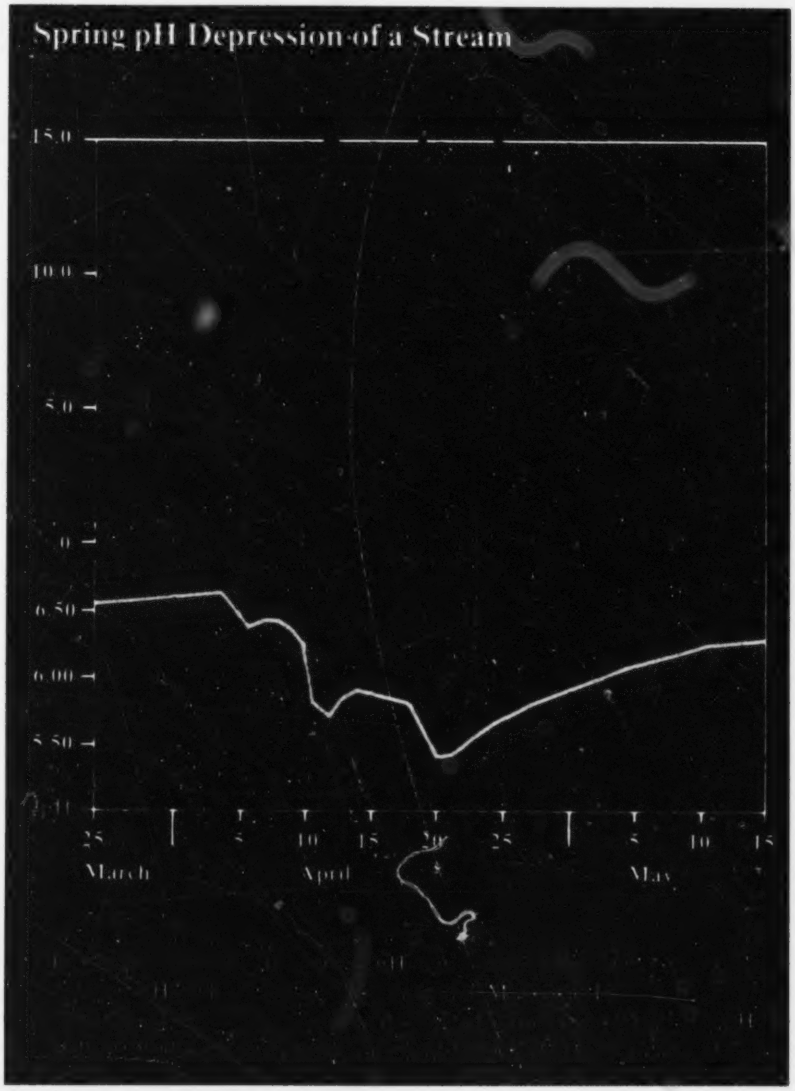
On the other hand, a waterbody with low alkalinity probably will have a pH somewhat below 7.0, that is, the water will be slightly acidic. This situation poses no particular problem for many species under normal conditions because a healthy aquatic environment can flourish in a slightly acidic medium and fish populations will be numerous and robust; for some species, such as trout, however, deleterious effects will begin to appear when the pH of the water falls below 6.

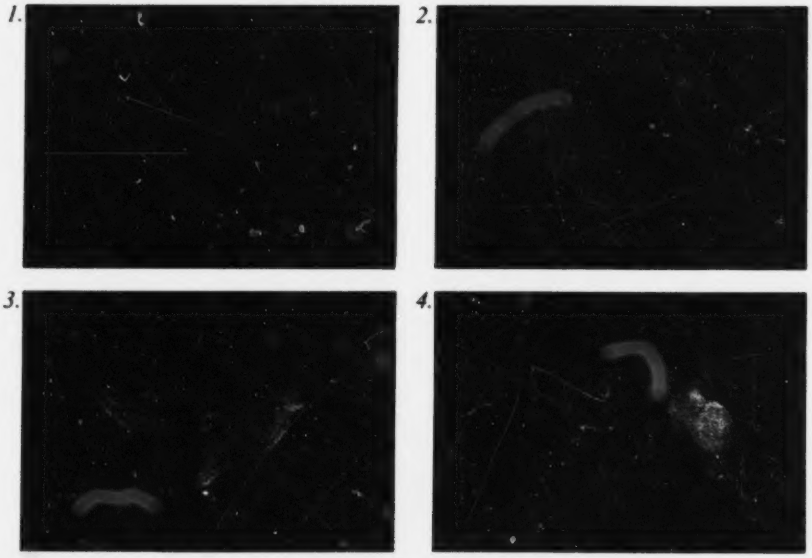
Lakes and streams with low alkalinities are susceptible to acid rain because they are unable to neutralize the incoming acid for very long. They are particularly susceptible to sudden and excessive acid loadings such as occur during the spring snow melt or during periods of exceptionally heavy rainfall.

Over a period of time, continual acid loading can exhaust the buffering capacities of sensitive geological zones, both on land and in water. The waterbodies are then assaulted not only by acid rain directly but by acidic runoff water from the de-buffered soils and rocks in the watershed.

These lakes and streams gradually become more and more acidic over time. As this happens, the most sensitive aquatic species begin to disappear entirely or exist only in certain age groups. When the pH of the water drops to about 4.5, most fish populations will have ceased to exist, and many other desirable life forms will have disappeared as well, or exist in greatly reduced numbers. At this point, the waterbody is referred to as "acidified". These effects have been observed for an extended period in Scandinavia and their occurrence in parts of Ontario and the Adirondacks of northern New York state is now being documented with increasing frequency.

The term "liming" applies to any mitigative procedure whereby the pH of an acidified waterbody is raised. A number of substances have been used in liming programs,





1. A normal, live Atlantic salmon alevin showing body pigmentation and noticeable heart and vitelline vein. 2. During the hatch process this alevin has freed only it's tail, a common condition in waters of pH 4.0 - 4.5. 3. This alevin died in acid waters of pH 4.0. 4. This alevin died in acid waters of less than pH 3.5.

including limestone, soda ash, potash, dolomite, calcium hydroxide, and calcium oxide. All have been used with various degrees of success but the application of limestone has proven to be the cheapest procedure. Liming has two beneficial effects: first, it neutralizes the acid in the water and immediately raises the pH; second, it restores to the water, at least for a period, a degree of buffering capacity so that the higher pH can be maintained in the face of additional acid rain input.

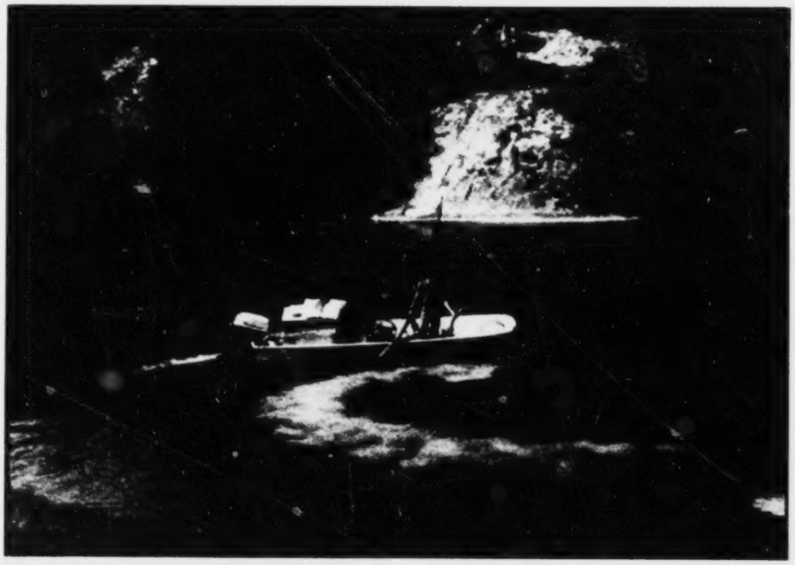
Liming of lakes has been carried out in Sweden for many years and also in parts of Ontario and New York State. The available evidence indicates that in some acid sensitive lakes the fish populations and supporting life forms can be restored and/or protected by this procedure.

Nelson Lake in Ontario, for example, with an area of 304 hectares, is located about 32 kilometres north of Sudbury. The lake was acid-stressed but some fish still lived in the waters and, fortunately, the heavy metal concentrations were low. Over a two-year period, nearly 45 tonnes of powdered lime and limestone were added to the lake and the pH was restored to normal. It appears that the fish populations in the lake will eventually be restored and a productive fishery can be re-established.

The Sub-committee received evidence from Mr. Eric Lykke of the Norwegian Ministry of Environment that Norway has embarked upon a study of liming. Mr. Lykke suggested that liming could have beneficial effects in restoring fish populations in certain selected waterbodies but he was emphatic in stating that "...liming is not going to provide us with anything more than a stopgap solution to selected lakes and small creeks and rivers... There is no question of us being able to apply lime in such a way that we will move back to where we were before we acquired this problem."

Dr. Hans Martin of Environment Canada provided the Sub-committee with evidence concerning the Mersey River in Nova Scotia where water acidification had destroyed a salmon hatchery: "...it was finally determined that the incoming water was too acidic for the production of the young fish. Subsequently they introduced limestone cribs which raised the pH, and now the hatchery is operating successfully."

An aspect of water acidification



Evidence has shown that the liming of some acid sensitive lakes can help in the restoration of depleted fish populations as well as supporting life forms.

that is particularly disturbing is the observation that, as the pH is lowered, there are increasing concentrations of toxic mercury in fish. There is some evidence to indicate that the relatively innocuous dimethyl mercury (an organic form of mercury) becomes transformed under acidic conditions to monomethyl mercury which is much more soluble in water than the dimethyl form and is apparently more readily taken up by fish and other aquatic organisms. Monomethyl mercury (also commonly referred to simply as methyl mercury) is extremely toxic to most living organisms, including humans. Methyl mercury poses a particular danger because it is subject to "bioaccumulation"; that is, the concentration of the chemical is greater in higher organisms than in lower organisms. Fish eaten by humans may contain very toxic concentrations of methyl mercury. This chemical was responsible for the tragedy of Minamata in Japan a number of years ago.

Concern for this particularly dangerous aspect of lakewater acidification was expressed by Mr. Allan Penn who testified before the Sub-committee on behalf of the Grand Council of the Crees of Quebec; the Cree populations in northwestern Quebec rely on indigenous fish populations for a major part of their diet. There is concern in this area of Quebec that the acidification of surface lake waters is linked to an accelerated accumulation of toxic methyl mercury in fish. Methyl mercury poisoning has been a public health issue in this region since 1975; medical studies in 1975 and 1976 indicated that mercury-related disease had occurred in some individuals. Although the waters in northwestern Quebec are contaminated by mercury from natural sources and local industrial sources, there is grave concern that the long-range transport problem can exacerbate the situation.

Mr. Penn recommended to the Sub-committee that the situation was serious enough in this area to justify the study of a program of remedial liming to prevent further acidification of the waters and a consequent worsening of the mercury poisoning problem.

This salmon hatchery in the Mersey River, Nova Scotia had been completely destroyed by high water acidification levels. The introduction of limestone chips in cribs has restored it to a successful operation.

The Sub-committee is aware that there are problems with the liming of waterbodies. First, adding limestone to a lake or stream will raise the pH of the water but will not, as Mr. Lykke pointed out, return that lake or stream to a natural state. Second, liming is an expensive procedure and the financial cost of the treatment must be carefully balanced against the costs to be incurred if the waterbody is left in an acidified state. Third, the costs and physical difficulties of liming lakes in remote areas where road transportation is rudimentary or nonexistent undoubtedly make the procedure unattractive and perhaps impossible.

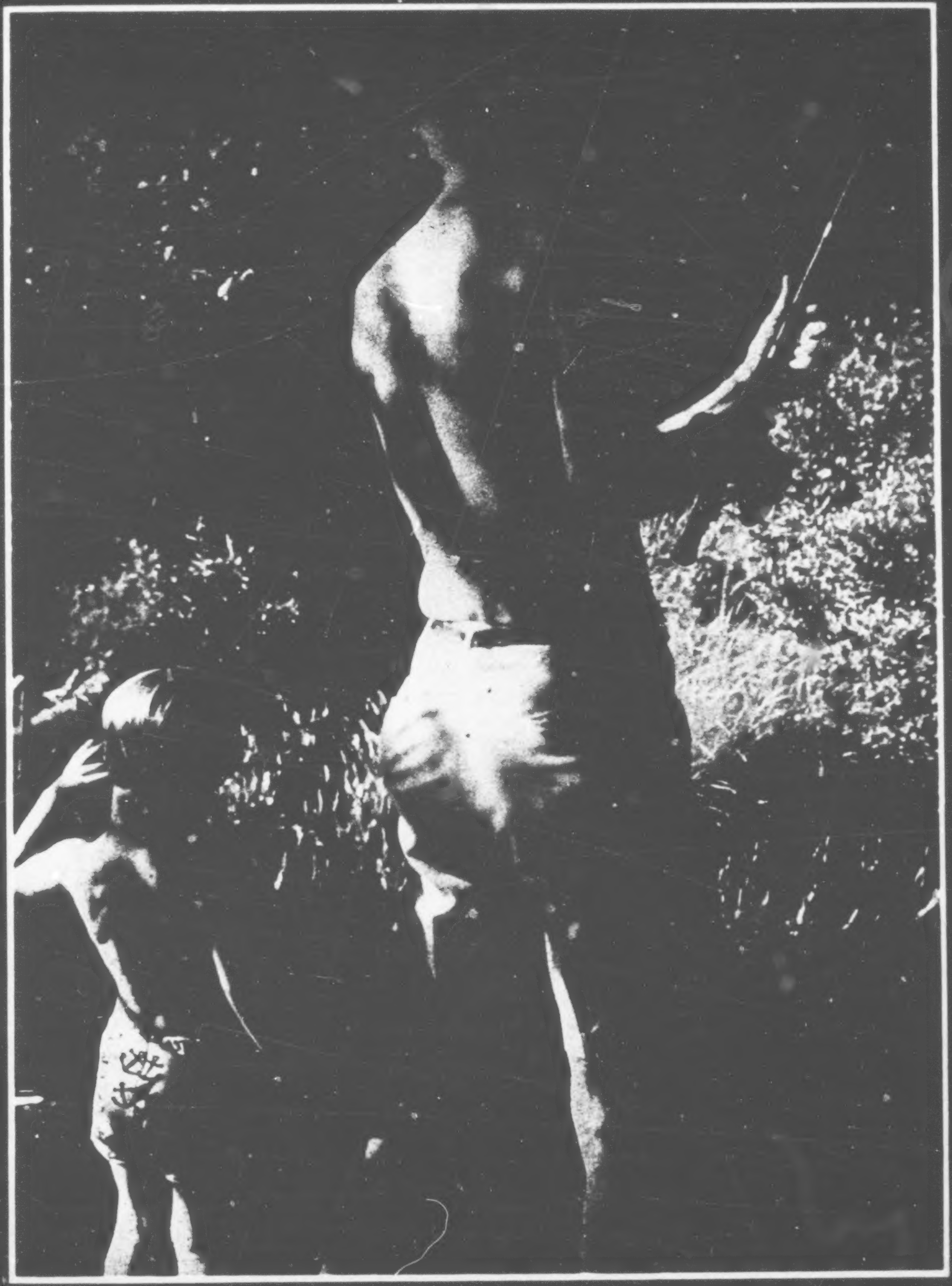
The Sub-committee concludes that remedial liming of *selected* waterbodies is an option that governments should carefully evaluate in areas of special concern only; several examples of such areas are cited above.

It is abundantly clear to the Sub-committee that the task of adequately liming watersheds and lakes on a general basis in any region of Canada represents an impossible undertaking. *This observation underscores our overall conclusion that the only practical long-term solution to the acid precipitation problem is the control of sulphur and nitrogen oxide emissions at source; no mitigative strategy applied after acidification has occurred will successfully restore the damaged environment to a normal state.*

Recommendation 15

The Sub-committee recommends that liming, as a mitigative strategy against acid rain damage, be considered by governments only for selected waterbodies to raise the pH of the water to restore and/or protect desirable fish populations. The Sub-committee emphasizes that liming must not be regarded as a substitute for the control of acid rain-causing emissions at source.

HEALTH EFFECTS



There is a general consensus among health authorities that acid rain precursors, particularly sulphur dioxide, sulphates, and nitrogen dioxide, may produce respiratory and other internal disease when such substances are inhaled at high levels. The Sub-committee is persuaded, therefore, that programs which will abate acid rain-causing emissions at source will produce tangible benefits for human health by reducing the level of toxic air pollutants.

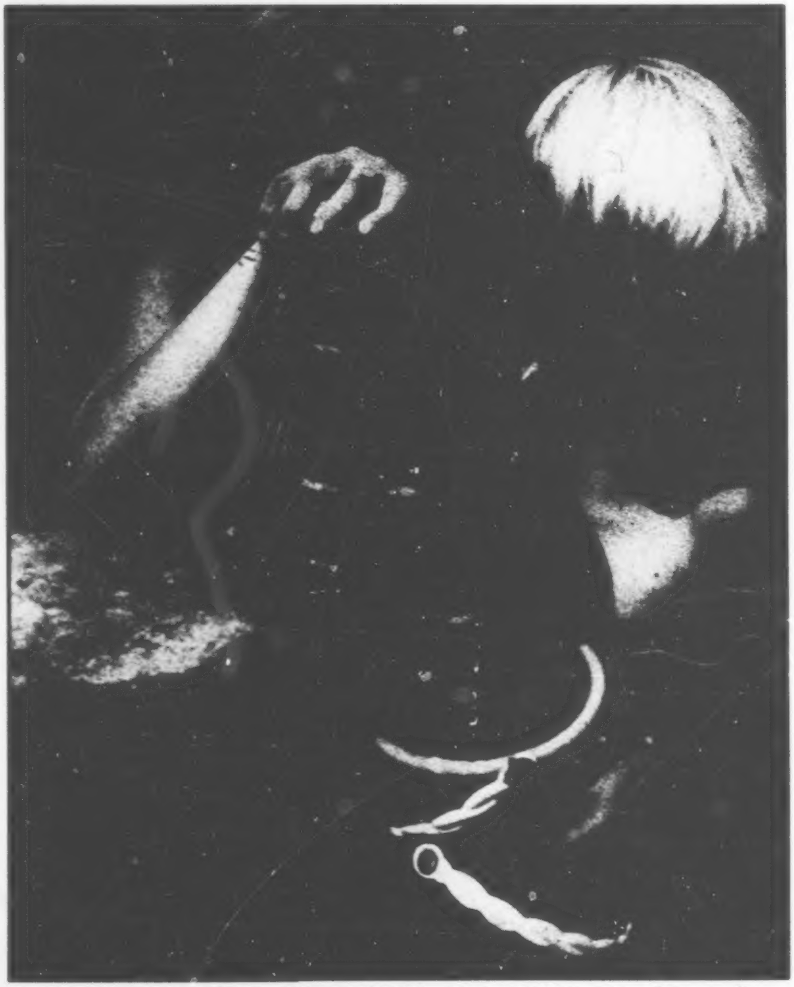
Perhaps the most dramatic and frightening example of the health effects of air pollution occurred in London, England in 1952. For several days of that year, a suffocating smog blanketed the city. Within two weeks the mortality rate had risen by 70 per cent; 4,000 deaths were eventually attributed to that smog "episode". We have already noted in this report that acid rain precursors are the principal ingredients leading to the formation of photochemical smog.

Studies in the United States by Mendelsohn and Orcutt on the effects of a number of air pollutants on mortality rates among U.S. adults indicated that sulphates were a particular hazard; sulphur dioxide produced less important effects. The authors concluded that between 10.2 and 13.2 per cent of all deaths of adult whites in the United States could be ascribed to exposure to atmospheric sulphates. These pollution-related death rates were greatest in the industrial northeastern and north-central states where sulphate exposures are most concentrated.

Acidic precipitation does have potentially serious indirect effects on human health. The available evidence indicates two important areas of concern: (1) the leaching of toxic chemicals from watersheds and from water storage and distribution systems, leading to contamination of drinking water supplies; and (2) the contamination of edible fish by toxic chemicals, principally mercury.

The contamination of potable water supplies by toxic metals is probably not a serious problem for most Canadians. Testimony given to the Sub-committee by Health and Welfare Canada indicates that "during the treatment of water in municipal water plants quite commonly the pH of water is adjusted for technological reasons..." and, therefore, the risk from acid precipitation is removed. However, there remains the concern that many Canadians, particularly those who live in rural areas for all or part of the year, are at risk due to the effects of acidified water supplies. Many of these people are drinking water from wells or from similarly untreated sources and such waters may contain toxic concentrations of certain chemicals, such as heavy metals.

The situation is not adequately defined at present; it is not known how many people are at risk or how severe the water contamination might be. There is some evidence from both Canada and the United States that violations of drinking water standards may be occurring. *Although the number of people at risk may be small in relation to the total Canadian population, the Sub-committee does not believe*



Concern is growing for the effects of acid rain on drinking water from wells and other untreated sources. Evidence has shown that, particularly in rural areas, water may contain high levels of toxic metals.

that this justifies any complacency on the part of health and environment authorities.

Recommendation 16

The Sub-committee recommends that the federal Department of Health and Welfare and the Department of Environment, in cooperation with provincial authorities, accord high priority to a research program to identify levels and species of toxic metals in potable water supplies in Canada with special emphasis being given to those areas under greatest impact from acid precipitation.

There is evidence to suggest that fish populations in poorly buffered waters with subnormal pH have elevated levels of mercury in their tissues. In Sweden, in 1972, it was noted that in certain lakes there was an inverse relationship between the pH of the water and the methyl mercury content of the fish; that is, the lower the pH, the higher the methyl mercury content. Some North American studies have similarly found high mercury levels in fish from poorly buffered lakes and streams; Quebec, New Brunswick, Minnesota, New York and Maine were included in these studies.

The mechanisms by which acid deposition might increase the mercury content of fish are not known, but both biological and chemical processes are believed to be involved. Two inorganic forms of mercury and two organic forms of the element may participate in the various reactions. Numerous investigators have shown that inorganic mercury can be transformed into the more pervasive and toxic organic forms in aquatic and terrestrial ecosystems. One hypothesis indicates that, at low pH (below pH 7) monomethyl mercury is formed, while at a pH above 7, the less hazardous dimethyl mercury is formed.

The methyl mercury present in some game fish presents a real health hazard.

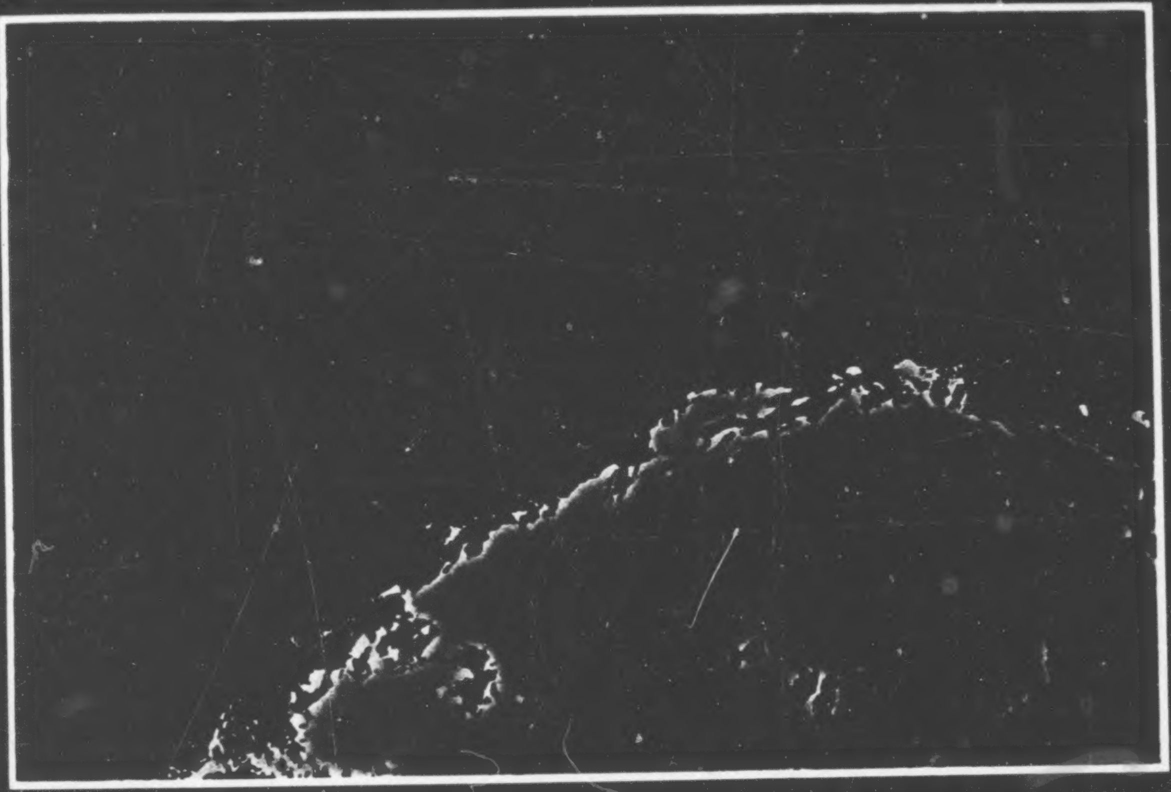
Monomethyl mercury, or methyl mercury, is efficiently taken up by living organisms and becomes concentrated in their tissues. Larger organisms such as game fish, which feed on smaller organisms, develop dangerous concentrations of methyl mercury in their tissues through a process known as "bioaccumulation". Humans, and other carnivorous animals, who eat large quantities of such contaminated fish may be at great risk from methyl mercury poisoning. Methyl mercury is a dangerously toxic chemical which accumulates in the human body and can cause irreversible nerve damage (including brain damage) and may result in death in the most extreme cases.

The evidence linking methyl mercury contamination of fish with acidic precipitation is not unequivocal and additional research needs to be carried out to clarify the situation. Nevertheless, there is sufficient concern about the dangers associated with this aspect of acid rain to warrant concentrated research and public health monitoring programs.

Recommendation 17

The Sub-committee recommends that the Federal Government examine its research program to ensure that adequate funding is being provided for research to determine the relationship between acidic precipitation and mercury contamination of fish in sensitive lakes and streams. We further recommend that suitable public health monitoring programs be initiated to determine the degree of risk faced by those populations whose diet contains large amounts of fish from sensitive areas.

MONITORING ACID RAIN



An important component of the overall research program on acid rain is the continuous and systematic monitoring of acid deposition. This is particularly important in sensitive areas of Canada where environmental damage is most likely to occur. It is also necessary to coordinate the information obtained from monitoring the deposition of various pollutant species with scientific data on the damage that may be occurring in the area(s) under study.

The Sub-committee received evidence from several witnesses that monitoring of acidic deposition and of subsequent environmental damage in Canada needs to be improved. For example, Dr. Harold Harvey of the University of Toronto, one of the world's most prominent acid rain researchers, informed the Sub-committee that there is a need for more research to demonstrate a cause-effect relationship for acid precipitation in Canada. This is not to suggest that there is any substantial disagreement among reputable scientists that the Canadian environment is being damaged by acid rain. What is lacking, however, is a detailed body of data on historical trends in acid deposition, a comprehensive overview of the seriousness of the problem in various regions of Canada, and a precise quantitative assessment of acid rain damage and rates of acidification in areas of differing sensitivity.

Monitoring of the chemistry of precipitation has not, historically, been consistent in North America. Scientists in Europe initiated a large and comprehensive international network of monitoring stations in the mid-1950s and this network has been maintained more or less intact since its inception. In Canada and the United States, however, the precipitation chemistry monitoring effort has been of limited scope and only recently has a commitment been made to long-term monitoring on the North American continent.

There are currently some 12 precipitation chemistry monitoring networks operating in Canada; some are operated by the Federal Government, through Environment Canada, and others operate under provincial authority.

A list of Canada's precipitation monitoring networks is shown in Appendix I. The Canadian Network for Sampling Precipitation (CANSAP), Canada's largest monitoring network, is a long-term, countrywide system and provides data on the chemical composition of precipitation. The CANSAP program began in 1977 and is designed to sample wet deposition only. As of December 1980, there were 54 CANSAP stations, from Gander, Newfoundland in the east to Terrace, British Columbia in the west, and from Harrow, Ontario in the south to Mould Bay, Northwest Territories in the north. Ontario has 12 CANSAP stations, more than any other province or territory. The greatest density of CANSAP stations is found in the lower Great Lakes-St. Lawrence Valley region and in southern Alberta. The network is operated by Environment Canada's Atmospheric Environment Service.

Other monitoring networks in Canada have a regional orientation and include the Acidic Precipitation in Ontario Study (APOS) network run by the Ontario Ministry of the Environment, and the Great Lakes Precipitation Chemistry network operated by the Inland Waters Directorate of Environment Canada. The major national network in the United States is that operated by the National Atmospheric Deposition Program (NADP), a cooperative program involving numerous U.S.

Canadian and American Monitoring Stations

Federal fisheries scientists from the Freshwater Institute continue to conduct tests in the Experimental Lakes area southwest of Kenora, Ontario in order to answer the vital questions posed by the acid rain threat.

federal, state and private research agencies. The NADP network will eventually include more than 90 monitoring stations nationwide.

There are several research support networks in Canada, including the six-station Ontario Hydro network and the seven-station Air and Precipitation Monitoring Network (APN) operated by the Atmospheric Environment Service of Environment Canada. Comparable networks in the United States include the Electric Power Research Institute (EPRI) network, and the Multi-State Atmospheric Power Production Pollution Study (MAP3S) network, an eight-station network monitoring acid deposition in the eastern United States.

The increased monitoring activity in North America over the past five years has produced a comprehensive set of data on acidic deposition. It has been concluded, on the basis of monitoring data, that intense acidic deposition is occurring in the northeastern part of the United States and the southeastern part of Canada. The precipitation acidity appears to be spreading toward the southeast and midwest; all U.S. states east of the Mississippi River are now receiving some acid rain. Also, some areas on the west coast of North America, including British Columbia and Northern California, are receiving acidic precipitation, a conclusion based on data from recent monitoring efforts.

An important consideration in the successful monitoring of acidic precipitation is the necessity of ensuring that the data obtained from the various networks will be comparable. With 12 networks in place in Canada and a number of separate networks operating in the United States, the potential difficulties that could accrue from disparate monitoring standards are obvious.

Within Canada, the degree of standardization of precipitation collectors in the different networks and of analytical procedures utilized by various laboratories is apparently increasing. Differences still remain, however, in criteria used for locating the collectors; also, sampling protocols, for example whether samples will reflect a single precipitation event, or cumulative weekly or monthly samples, have still to be standardized.

Recommendation 18

The Sub-committee recommends that Environment Canada, in consultation with appropriate provincial ministries, carry out a comprehensive review of all aspects of monitoring acidic precipitation in Canada. Of particular importance is the need for standardized methodology to permit ready comparison of results obtained by the various monitoring systems operating in Canada.

There is also a need to ensure that monitoring data collected in Canada is comparable with that collected in the United States. Since the monitoring networks in the two countries were put in place for different reasons, they often use different operational and analytical procedures. With the advent of joint Canada-U.S. studies under the 1980 Memorandum of Intent, the situation is improving but there is a need for even more improvement.

Recommendation 19

The Sub-committee recommends that Environment Canada accelerate its efforts to make Canadian and United States precipitation chemistry monitoring systems compatible in terms of providing data of acceptable comparability.

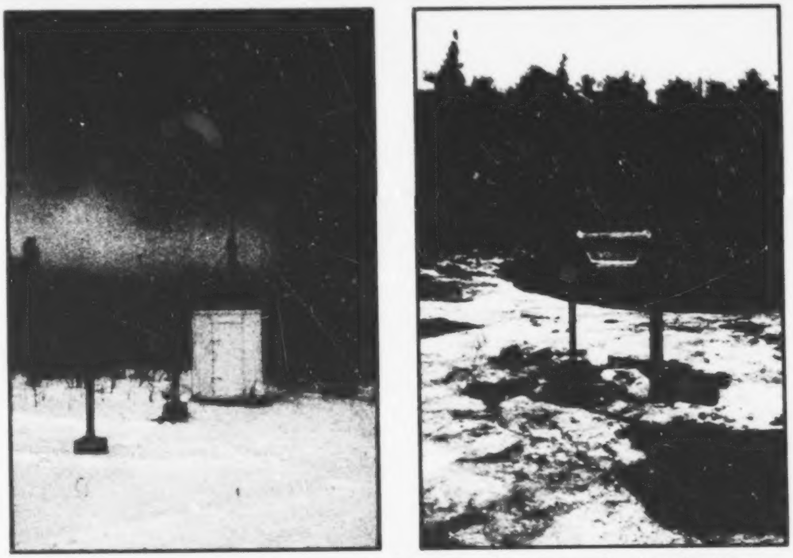
A major difficulty in monitoring acid rain is the lack of knowledge about "dry deposition". Although the term appears to be contrary to the concept of acid rain, some scientists estimate that 10 to 30 per cent of the acid precipitation problem may result from dry deposition.

Dry deposition may include the direct deposition of gases such as sulphur dioxide and nitrogen oxides. The gases may not transform to acids prior to deposition but become deposited directly into lakes or onto vegetation or other surfaces. Dry deposition of acid substances may also take the form of tiny particles of sulphates and nitrates which are not washed out of the atmosphere by precipitation but which ultimately land on various surfaces.

The monitoring of dry deposition is much more difficult than that of wet deposition and no accurate methodology has been developed to date. *The Sub-committee is aware of the problems involved with monitoring dry deposition but we believe that this component of acid precipitation is sufficiently important to justify a major and continuing research effort.*

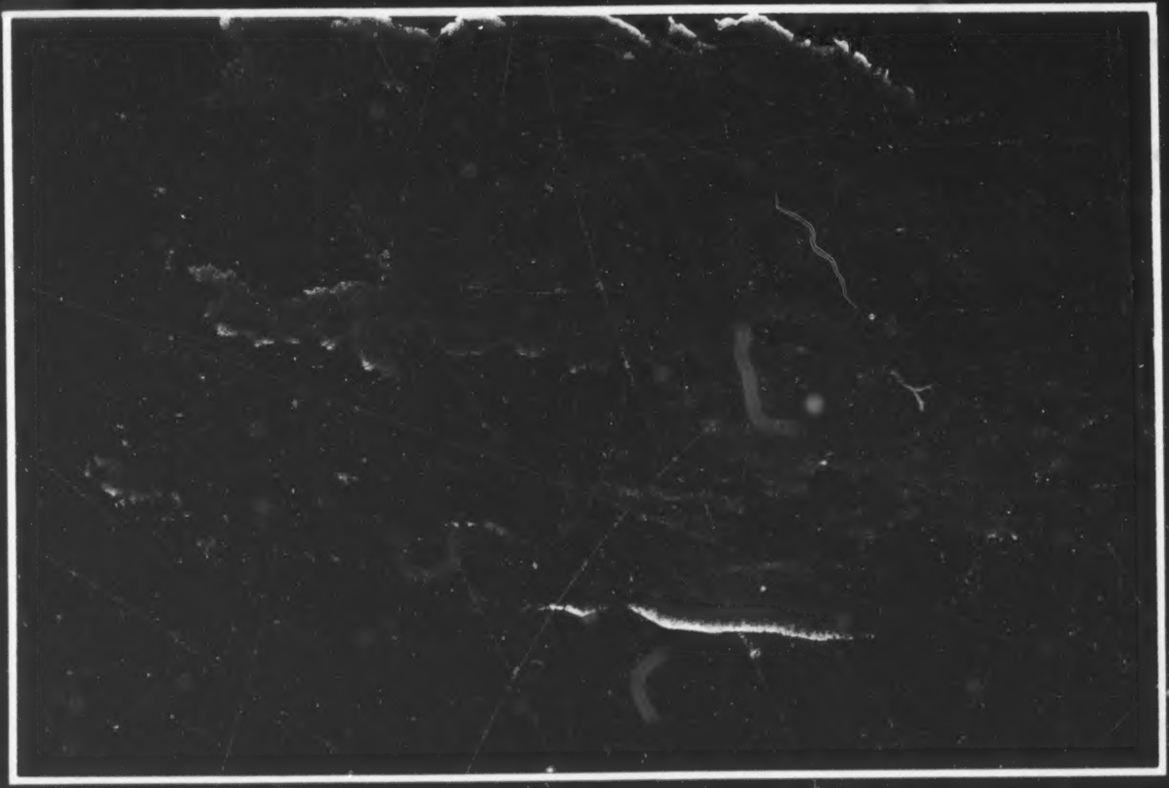
Recommendation 20

The Sub-committee recommends that the Federal Government provide appropriate funding for an effective research program to develop an accurate and reliable method for the monitoring of dry deposition.



Air filters mounted atop the tower in the wet collector monitoring device at left measure daily concentration levels. Note the two sangamo samplers, one for the CANSAP network, the second for the APN network. The dry deposition collector at right measures the direct deposition of acid substances that take the form of tiny particles of sulphates and nitrates.

THE FORECAST FOR ALBERTA



Alberta enjoys the most rapidly growing provincial economy in Canada and this growth is expected to continue far into the future. The petroleum industry forms the basis of Alberta's economy. One of the major costs of rapid economic growth in the industrial world is environmental pollution. Alberta already has the second highest levels of sulphur dioxide emissions in Western Canada. (Manitoba, with two large and uncontrolled non-ferrous smelters, is the largest source of SO_2 west of Ontario.) Most of this SO_2 emanates from the petroleum industry, specifically from the numerous natural gas processing plants in the province.

As we noted in an earlier section in this report, more than 40 natural gas processing plants are operating in Alberta today. The greatest concentration of gas plants is located in south-central Alberta, near Calgary. A second cluster of plants is located south and west of Edmonton. Although most plants emit relatively modest amounts of sulphur dioxide, several emit substantial amounts. The Aquitaine Company of Canada plant at Ram River emits about 58,000 tonnes of sulphur dioxide and is, by far, the largest polluter in this group. The second largest emitter of SO_2 in this group is the Chevron Standard plant at Kaybob South which discharges about 26,000 tonnes annually. The natural gas processing plants emit a total of about 892 tonnes of SO_2 per day, or approximately 326,000 tonnes per year.

The two tar sands plants at Fort McMurray emit about 20 per cent of the sulphur dioxide released into the atmosphere in Alberta each year. The Suncor synthetic oil plant (formerly the Great Canadian Oil Sands) is the largest point source for SO_2 in the province, releasing about 93,000 tonnes annually. The second tar sands plant, operated by Syncrude Canada Limited, emits 41,000 tonnes of SO_2 each year.

The Suncor synthetic oil plant at Fort McMurray is the largest point source of sulphur dioxide emissions in the province of Alberta, releasing 93,000 tonnes annually.

Sulphur dioxide emissions from Alberta's thermal electric power generating utilities amounted to 73,200 tonnes in 1980. Almost 60 per cent of the electrical-generating capacity in Alberta is fuelled by subbituminous coal which has a sulphur content of about 0.4 per cent. An additional 26 per cent of Alberta's electrical power is generated using natural gas. Only 15 per cent is generated from hydro sources.

The Alberta environment is not, at present, suffering measurable damage from acid rain. The soils and surface waters in Alberta generally are well buffered and resistant to damage from acid precipitation. There is evidence also that air masses passing over the Rocky Mountains and across the western prairies pick up calcareous (limestone) dust which tends to neutralize any acidic precipitation that may be formed in the atmosphere. Nevertheless, evidence presented to the Sub-committee by Alberta's electric power industry showed that there are episodes of precipitation in Alberta as low as pH 4.3, although the yearly average is higher than pH 5.6.

The present situation in Alberta, then, is apparently in a state of acceptable balance. The future, however, has engendered considerable concern among members of the Sub-committee.

Alberta will use coal as the mainstay of electric power generation capacity for the future. Alberta coal, as noted, has a low sulphur content and the electric power utilities in the province have no plans to install flue gas scrubbers on new or currently operating power plants. This means that, with a 5 per cent annual growth in electric power generation, sulphur dioxide emissions will increase more than four-fold from 73,200 tonnes per year in 1980 to an estimated 312,000 tonnes by 2005.

Annual sulphur dioxide emissions from the natural gas processing sector are projected to remain essentially stable until 1990 and to gradually decline after that date unless there is an unexpected increase in natural gas production.

The Sub-committee was gratified to learn at the Calgary hearings that sulphur removal technology for the gas processing industry has improved significantly in recent years. The Canadian Petroleum Association presented evidence that "from 1974 to 1978 inclusive, despite an

It is believed that the future development of tar sands in Alberta will greatly increase emissions of sulphur dioxide to more than double the present amounts.

increase in the number of emission locations from 60 to 71, the actual tonnage of sulphur emitted from gas plants decreased from 673 T/D to 446.8 T/D, a reduction of 29.9%." Sulphur recovery technology has progressed to a point now where, on average, 97 per cent of the sulphur dioxide in sour gas is removed by Alberta's processing plants. In the best situations, typified by the Shell Canada Resources Limited plant at Waterton, a combination of the Claus Process and tail-gas clean-up will permit a recovery of sulphur of 98.7 per cent when the plant is operating at full capacity and of 99 per cent when operating at two-thirds capacity.

The sector of most concern is the oil sands industry. With conventional oil reserves in steady and apparently irreversible decline, Canada needs new sources of domestic oil. The bitumen (oil sands) deposits near Fort McMurray and Cold Lake thus have been identified as a major source of domestic oil supplies for the future.

A "rapid development" scenario elaborated by the Alberta Energy Resources Conservation Board in 1978 projected that, by 1986, the Suncor Limited operation and the expanded Syncrude facility (both at Fort McMurray) would have attained full production capacity; together they would produce a total of 260,000 barrels of synthetic crude oil per day. A third bitumen mining plant (Alsands) would be in operation in 1986 and producing 125,000 barrels per day. Beyond 1987, new plants would come on stream every three to four years; some of these would be mining operations; others would be *in situ* operations wherein the bitumen would be liquefied underground and pumped to the surface. Each of these new plants would produce 210,000 barrels of synthetic crude per day.

The timetable for future oil sands development has now been thrown into limbo as a result of oil-pricing negotiating problems between Ottawa and the Alberta Government but there is little doubt that development of this vast energy resource will ultimately take place. When these projected oil sands operations come on stream, emissions of sulphur dioxide in Alberta will increase significantly. The two oil sands plants presently operating emit about 134,000 tonnes of sulphur dioxide each year. Syncrude Canada Limited informed the Subcommittee at the Calgary hearings that, by 2006, with a projected 10-fold increase in oil sands production, emissions of sulphur dioxide would more than double to an estimated 336,000 tonnes annually.

Dr. U.T. Hammer, in his 1980 report to the Saskatchewan Environmental Advisory Council, gave a considerably higher estimate for sulphur dioxide emissions from oil sands operations by the year 2006. Dr. Hammer noted that the four projected *in situ* oil sands plants would burn 9.1 million tonnes (10 million tons) of subbituminous coal a year by 2006 to fuel their operations. The four *in situ* plants, plus four additional mining oil sands plants at Fort McMurray, could emit 1,720 tonnes of sulphur dioxide each day by 2006; this emission rate translates into about 628,000 tonnes of SO_2 each year, almost double the Syncrude estimate.

Dr. Hammer has noted that a great deal of progress has been made in reducing SO_2 emissions during the extraction of synthetic crude oil from the oil sands. The first oil sands plant, now operated by Suncor Inc., emitted 13 tonnes of sulphur (S) for each 1,000 cubic metres (m^3) of bitumen processed; the Syncrude Canada Ltd. plant emits 4.8 tonnes S/1,000 m^3 of bitumen. The proposed plants may reduce this level to 1.2 to 2.4 tonnes S/1,000 m^3. The Alberta Environment target is for an emission level of 1.0 tonne SO_2/1,000 barrels of synthetic crude, and it is hoped that this target will be met by 1985-86. (1.0 tonne SO_2/1,000 barrels is equivalent to 3.15 tonnes S/1,000 m^3.) The Alberta target is, therefore, less exacting than the technological capability expected to be utilized by the proposed oil sands plants.

The planned use of vast quantities of coal, rather than natural gas, to fuel the *in situ* oil sands plants has cast doubt upon projections for SO_2

emissions from the combined oil sands operations because the combustion of coal releases far more sulphur per unit of energy than does natural gas. If, as is apparently the case, Alberta Environment will require only 90 per cent sulphur removal efficiency for these coal-fired installations, Hammer's estimate of total annual SO_2 emissions of 628,000 tonnes by the year 2006 may be much too low.

The estimates for total sulphur dioxide emissions from Alberta in 2006 indicate that the province will produce well in excess of one million tonnes from the three sectors discussed above: electricity generation, oil sands operations and natural gas processing.

Estimates for total NO_x emissions from Alberta by the year 2006 are not available. It is clear, however, that emissions will increase substantially from the oil sands operations and from electrical power generation. In 1979, nitrogen oxides emissions from major sources in Alberta totalled 314,573 tonnes. In 1978, sulphur dioxide emissions in Alberta totalled about 550,000 tonnes. If NO_x emissions increase at the same rate as SO_2 emissions by 2006, the total for the province may approach 700,000 tonnes.

The Sub-committee is very concerned about the trend toward greatly increased emissions of sulphur dioxide and nitrogen oxides in Alberta. There is evidence already of acid rain falling in the Cree Lake area of Saskatchewan and it has been suggested that the acid was sourced in Alberta. Vast increases in emissions of acid rain precursors in Alberta pose a threat to sensitive regions in northern Saskatchewan and perhaps in similarly sensitive areas farther east in Manitoba.

We have no wish to make recommendations that will disrupt or unduly delay the development of Alberta's economy. *Nevertheless, we are convinced that it is essential to pursue industrial development utilizing the best available emission control technologies.* The Sub-committee commends and wholeheartedly supports the approach described by Dr. Martin Winning of Shell Canada Resources Ltd. Dr. Winning, testifying on behalf of the Canadian Petroleum Association, stated:

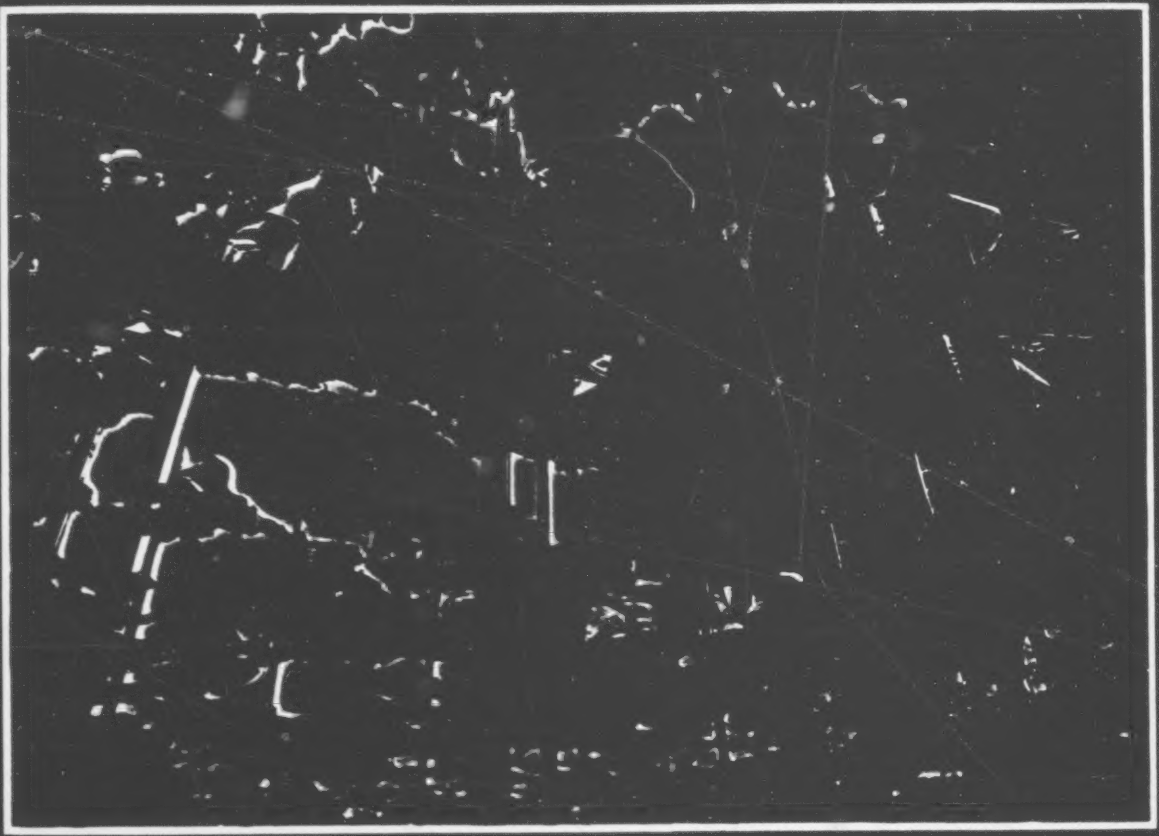
> *We are taking the approach that we do not want the SO_2 or the NO_x from our industry to be the cause of...(acid rain)... We have cleaned it up. We are going to keep on cleaning it up...we do not want people coming to us in 10 years saying, hey, you have ruined half of Canada. We would rather spend the money, clean up our emissions and not let it become a long-term problem for our kids to look after.*

Throughout North America, efforts are being made to reduce acid rain-causing emissions below present levels; it is most disturbing, then, to see a Canadian province embarking on a course of development that will result in the doubling of emissions of acid rain precursors over the next 25 years. Dr. Martha Kostuch, representing the Public Advisory Committee to the Environment Council of Alberta, recommended in her testimony to the Sub-committee the setting of "a goal of zero increase in total sulphur emissions (in Alberta) up to 1990 and an annual decrease by a prescribed amount each year thereafter." The Sub-committee agrees with the tenor of this suggestion, and we make the following recommendation.

Recommendation 21

The Sub-committee recommends that the Government of Alberta accord maximum priority to the control of acid rain-causing pollutants from industries in the province. The Sub-committee recommends that the Provincial Government adopt as its guiding policy a goal of zero increase in acid rain-causing emissions over present levels up to the year 2000, and an annual decrease by a prescribed amount each year thereafter.

THE LEGAL CONTEXT



As one of the most serious environmental problems facing Canadians today, acid rain must in part be dealt with through effective legal and administrative tools supported by a political will determined to prevent damage caused by acid rain by reducing emissions into the atmosphere.

Some of the legal and administrative tools now available are sufficient to attack the acid rain problem — others are not and will have to be improved, and certain new regulatory approaches will have to be developed. Any concerted attempt to reduce acid rain will require a high degree of federal-provincial co-operation which the Sub-committee is confident will be forthcoming. There may, however, be occasions when actions against acid rain will have to be Canada-wide — the Sub-committee has recognized such circumstances and recommends specific measures in this area.

Although vigorous policies and legislation are necessary to reduce acid rain-causing emissions in Canada, the reality of this problem is that a large proportion of the precursor pollutants comes from sources in the United States. In this part of its report the Sub-committee comments on the present Canada-United States negotiations which are aimed at producing an agreement on the long-range transportation of air pollutants.

Before embarking on the proposal and discussion of its recommendations in this part of its report, the Sub-committee will briefly describe the legal context within which air pollution, and more particularly acid rain, is considered in Canada.

The 1867 **British North America Act** does not allocate legislative jurisdiction over the environment to either the federal or provincial level of government. Environmental matters were not considered to be of consequence in the nineteenth century and, hence, the Fathers of Confederation did not discuss them during their deliberations in Canada and Great Britain between 1864 and 1867.

As a result of this deficiency, the federal and provincial levels of government share jurisdiction over environmental matters. Under s. 91 of the **British North America Act**, the Federal Government can exercise jurisdiction over the environment by virtue of its legislative power over navigation and shipping, sea coast and inland fisheries, and the criminal law. It may also exercise such power by virtue of its jurisdiction over emergency situations with national implications, extraprovincial trade and commerce and its grant of the residue of undistributed legislative powers.

Under s. 92 of the **British North America Act**, the provinces deal with environmental matters by virtue of their legislative jurisdiction over municipal institutions in the province, local works and undertakings, property and civil rights in the province and all matters of a local or private nature in the province.

Because of this legislative division of jurisdiction, the provinces have primary responsibility for the control of intraprovincial air pollution (that which originates and has effects within one province). The Federal Government has jurisdiction over extraprovincial air pollution (that which originates within a province and has effects beyond its borders) or may legislate in reference to intraprovincial air pollution under the criminal law power when it represents a danger to public health or safety.

The Federal Government has exclusive jurisdiction to negotiate and conclude treaties and other types of international agreements. This jurisdiction does not give the Federal Government exclusive power to implement the terms of any such treaty or international agreement. Such implementation is effected in accordance with the division of legislative jurisdiction set out in the **British North America Act**. Consequently, the effective implementation of any Canada-United States agreement on the long-range transportation of air pollutants will require both federal and provincial action. This reality is recognized through provincial representation on the Canadian negotiating team. The Sub-committee commends both the Federal and Provincial Governments for this approach to the negotiation of the agreement.

The **Clean Air Act**, and its attendant regulatory instruments, is the primary federal legislative mechanism for dealing with the problem of air pollution and, hence, of acid rain-causing emissions. This legislation is dependent on close federal-provincial collaboration for its effective implementation. ***We believe that continued close federal-provincial collaboration is essential for concerted effective action to be taken against acid rain-producing emissions.***

The **Clean Air Act** is implemented by the adoption and application of four different types of regulatory instruments: National Ambient Air Quality Objectives, National Emission Guidelines, National Emission Standards, and Specific Emission Standards.

National Ambient Air Quality Objectives: These are prescribed by the Federal Government to reflect regional air quality goals in three ranges — 'tolerable', 'acceptable' and 'desirable'. The Objectives are not source-specific but are geographical area-specific. They are enacted to deal with specific air contaminants. They are enforceable by the provinces only if adopted by them as part of their environmental laws in virtue of a federal-provincial agreement under the federal **Clean Air Act**.

National Emission Guidelines: These are enacted by the Federal

Government and indicate the quantity and concentration beyond which an air contaminant should not be emitted into the atmosphere by a stationary or other type of source. These Guidelines are source-specific and are enforceable by a province only when they are adopted under provincial environmental law.

National Emission Standards: These are enacted by the Federal Government to establish maximum rates of air contaminants that may be emitted by a stationary source if such an emission is a threat to human health or would cause Canada to violate any international obligation it has undertaken in reference to air pollution abatement. Such Standards do not require provincial adoption to be enforceable; in other words they may be directly enforced by the Federal Government.

Specific Emission Standards: Where a National Ambient Air Quality Objective has been adopted, the Federal Government may adopt and enforce Specific Emission Standards to establish maximum rates of air contaminants emitted by a stationary source under federal jurisdiction. The Federal Government may also adopt and enforce a Specific Emission Standard which will be applicable to any work in a province that has incorporated the relevant National Ambient Air Quality Objective into its environmental legislation. Under a recent amendment to the federal **Clean Air Act**, Bill C-51, the Federal Government may adopt a Specific Emission Standard where an emitted air pollutant constitutes a significant danger to the health, welfare or safety of persons in another country. This legislative power can be used only where a similar provision is contained in that other country's environmental law. Since such a provision is contained in the U.S. **Clean Air Act**, the Federal Government has the power to adopt and enforce a Specific Emission Standard within a province.

This, very briefly, sets the legal context within which any effective program aimed at the reduction of acid rain-causing air pollution must operate. In considering the problem of acid rain, the Sub-committee has concluded that certain legislative changes are necessary and we shall now present and discuss these recommendations.

Clean Air Act

The sources of acid rain, sulphur oxides and nitrogen oxides, can be controlled by the application of effective regulatory schemes. *The Sub-committee is convinced that the control of emissions of sulphur dioxide and nitrogen oxides at source is the best legislative strategy and should be continued at both the federal and provincial levels of government.*

The Sub-committee has received considerable evidence and opinion about the national role of the Federal Government in taking strong, concerted action to control acid rain-causing emissions of nitrogen oxides and sulphur dioxide. Frequently, the Federal Government has been severely criticized for taking a less than active national role in controlling acid rain-causing air pollution.

Charles Mallory, Director of STOP, a Montreal-based environmental group, told the Sub-committee that the Federal Government's involvement must be amplified. He said:

> *A lax federal stance encourages lethargy and the problems fester. More aggressive federal action will both encourage provinces to defend jurisdiction they no doubt see as their own and protect Canadians against the development of pollution havens within our own country.*

L.J. Lechner of the Saskatchewan Department of the Environment expressed the following expectation to the Sub-committee:

> *We expect the Federal Government to show leadership and imagination in ensuring acid rain problems are avoided in Saskatchewan.*

Dr. S.G. Smith of the Alberta Society of Professional Biologists expressed the following opinion before the Sub-committee:

> *I think our first concern relates to the need for establishment of a national policy for control of acid precipitation. There is no such policy presently operating in Canada.*

Although the Sub-committee agrees with the general tenor of these sentiments and reflects this view in its recommendations for a greater federal role in the reduction of acid rain-causing air pollution, it believes that this environmental problem can only be effectively combatted by close federal-provincial co-operation.

In its Brief to the Sub-committee, the Canadian Environmental Law Research Foundation described the situation in the following terms insofar as National Ambient Air Quality Objectives are concerned:

> *As concerns Canadian Regulatory Instruments, the major federal one is of course the Clean Air Act, which sets three ranges of air quality objectives: desirable, acceptable and tolerable. The obvious problem with these objectives is that they are only advisory, and have no legal effect unless they are incorporated into provincial approvals or regulations. Alberta, Manitoba, New Brunswick, Ontario and Saskatchewan have all adopted ambient standards keyed to those objectives. While Labrador, Newfoundland, Nova Scotia, Prince Edward Island and Quebec (in general the less important polluters) have not.*

While federal-provincial consultation is ideal, it is hoped that the Federal Government will exercise increased authority over sources of interprovincial acid rain.

British Columbia has established a permit system for air pollution emissions which is similar in effect to the ambient standards approach.

In its testimony before the Sub-committee, the Newfoundland Department of the Environment indicated that it had recently adopted air quality regulations which comply with the National Ambient Air Quality Objectives.

The Federal Government has enacted National Ambient Air Quality Objectives for sulphur dioxide and nitrogen oxides which have been adopted by the five provinces cited by the Canadian Environmental Law Research Foundation and by Newfoundland.

Under s. 8 of the **Clean Air Act**, the Federal Government may publish National Emission Guidelines indicating maximum quantities and concentrations above which an air contaminant should not be emitted into the ambient air by either stationary or any other sources.

The Federal Government has established National Emission Guidelines for packaged incinerators, the cement industry, the metallurgical coke industry, the arctic mining industry, the asphalt paving industry, the pulp and paper industry, and new thermal power generating stations.

The National Emission Guidelines aimed at new coal-fired thermal power plants were adopted in April 1981. The Guidelines are based upon commercially available technology which can reduce emissions of nitrogen oxides by 50 per cent and sulphur dioxide by 90 per cent. *The Sub-committee welcomes the adoption of these most recent Guidelines and urges the provinces to take the necessary steps to ensure their immediate implementation. The Sub-committee believes, however, that these Guidelines should apply to all coal-fired thermal power plants whether they be new, already-existing or those which have been converted from oil and gas. The Sub-committee therefore urges the Federal and Provincial Governments to act quickly so that such extended Guidelines are immediately adopted and implemented.* Acid rain will not wait for excessive caution — its effects are too insidiously devastating.

The National Emission Guidelines thus far adopted have been source-specific and industry-specific. Except for the recently adopted new thermal power plant guidelines, there have been no other National Emission Guidelines aimed at the sources of acid rain.

National Emission Guidelines are dependent on incorporation into provincial environmental law for enforcement. Their adoption promotes uniform air pollution regulation across the country by Provincial and Municipal Governments and thus would ensure that sources of acid rain could be subject to the same norms no matter where they are located.

Recommendation 22

The Sub-committee recommends that the Federal Government develop comprehensive National Emission Guidelines (compulsory once adopted by a province) to cover all facilities, whether existing, converted, or new, which are sources of sulphur dioxide and nitrogen oxides, and hence of acid rain.

The Sub-committee has found that not all of the air pollution that results in acid rain is emitted in the province in which the pollutant is deposited.

Mr. L.J. Lechner of the Saskatchewan Department of the Environment told the Sub-committee of the inability of a province, such as Saskatchewan, to protect itself from sulphur dioxide emissions coming from neighbouring provinces because of the lack of legal authority to do so. Mr. Lechner said there is a need "...to establish a mechanism to ensure that emission limits in various jurisdictions will protect the environment and not harm other provinces."

When the Departments of the Environment of Newfoundland and Nova Scotia appeared before the Sub-committee, they indicated a concern about acid rain depositions originating from sources beyond their borders over which they have no legislative or regulatory control.

Under the division of legislative powers in Canada, the provinces have primary authority for the control of emissions from local sources causing air pollution. The Sub-committee agrees that in principle this should continue to be the case.

There are times, however, when it is necessary for there to be centrally-enforced environmental law standards on a Canada-wide basis — the far-reaching consequences of continued interprovincial unabated acid rain is one of these occasions.

In support of this point, former Ontario M.P.P. and then N.D.P. environmental affairs critic, Colin Isaacs, stated that:

> *Canada, under its federal system, has the potential for joint federal-provincial action and we believe that if the Federal Government, in response to the report of your sub-committee, comes out very strongly in this area and is prepared to take the leadership role, then we are convinced that the present Government of Ontario, or a future Government of Ontario, will join in hand with that and that there would not be federal-provincial bickering over acid rain but that there indeed could be a partnership to solve the problem here in Canada and to show leadership to our confreres south of the border.*

Former Ontario M.P.P., and then Liberal environmental affairs critic, Murray Gaunt, made a similar observation in the following terms:

> *...under certain circumstances I would feel the Federal Government would be justified in moving in a unilateral fashion to impose certain controls where they felt there is a serious problem and it is not being dealt with at the provincial level. I think, obviously, the better way to resolve these matters is on the basis of negotiation, conciliation and so on...*

In its June 1981 report entitled **Reforming Regulation**, the Economic Council of Canada made the following observation with which the Sub-committee agrees:

> *...the federal government requires broader powers to control the pollution that moves across provincial borders, for when most of the emissions are carried beyond the borders of a province, constituency pressure on its government to reduce the air pollution is not as strong as it would be if the emissions were deposited locally. Yet if sulphur dioxide pollution is not reduced sharply now, it will leave a legacy of destruction for future generations. Any reasonable concept of intergenerational equity requires that the present generation bequeath a benign environment to its heirs. We believe, therefore, that there is room for a stronger federal presence to control acid rain.*

As a consequence of this view, the Economic Council of Canada made the following recommendation:

> *We recommend that the Federal Government amend the* **Clean Air Act** *to give it the authority to regulate the sources of air contaminants that cross provincial boundaries.*

The Sub-committee believes that the **Clean Air Act** should be amended to enable the Federal Government to adopt Standards where the air emissions causing acid rain originate in a province and have their effects beyond its borders. In a situation such as this, neither the emitting nor the receiving province may have clear jurisdiction to deal with it. Because the Sub-committee believes that the primary responsibility for air pollution control should remain with the provinces, it is submitted that the provinces should be consulted before any such new Standards under an amended **Clean Air Act** are adopted to deal with emissions resulting in extraprovincial acid rain.

In coming to this conclusion the Sub-committee has attempted to respect the flexibility and accommodation inherent in the Canadian federal system insofar as it applies to the area of environmental protection; the provinces would continue to have primary authority for the control of air emissions causing acid rain. *However, where uniform provincial controls are not possible or are not sufficiently stringent, the federal authority over sources of extraprovincial acid rain could be invoked after consultation with the provinces.*

We are hopeful that federal-provincial consultation will result in the uniform application of National Emission Guidelines to facilities which are sources of sulphur dioxide and nitrogen oxides, and that it will not be necessary to develop National Emission Standards in this area.

Under the December 1980 amendments to the **Clean Air Act** contained in Bill C-51, the Minister of the Environment can seek authority to control individual emission sources affecting the health, welfare or safety of persons in another country only after attempting to effect control through provincial law and seeking the advice of the Provincial Government involved.

In coming to a conclusion in this area, we are applying the philosophy underlying the December 1980 amendments to instances of transboundary air pollution within Canada insofar as acid rain is concerned.

The implementation of the Sub-committee's finding would require an amendment to section 7 of the **Clean Air Act** — such an amendment could be enacted under Parliament's jurisdiction over criminal law or extraprovincial trade and commerce, or under its national dimensions residual power.

Recommendation 23

The Sub-committee recommends that the *Clean Air Act* be amended to enable the Federal Government to develop National Emission Standards to cover sources of sulphur dioxide and nitrogen oxides resulting in interprovincial air pollution and acid rain.

The Sub-committee has been informed that a major source of acid rain-causing air pollution is concentrated in the non-ferrous smelting industry, particularly in the Sudbury Basin in Ontario and in Rouyn, Quebec.

Former Ontario M.P.P., and then Liberal environmental affairs critic, Murray Gaunt, testified before the Sub-committee that...

> *...the recent control order by the Ontario Government on the Inco smelter in Sudbury is too weak. The company is presently allowed to emit 2,500 tons of SO_2 per day and, under this new order of a few weeks ago, has been asked to get down to 1,950 tons per day by 1983 ...studies by the federal Department of the Environment and the Economic Council of Canada have indicated that Inco's emissions could be reduced to 1,000 tons per day, or less, over a five year period at a cost of approximately $425 million, much of which could be recovered by the company in terms of energy savings.*

Under ss. 20 and 21 of the **Clean Air Act** the Federal Government presently has the authority to enact and apply Specific Emission Standards in provinces which by federal-provincial agreement have incorporated National Ambient Air Quality Objectives into their environmental protection legislation.

The provinces of Alberta, Manitoba, New Brunswick, Newfoundland, Ontario and Saskatchewan have adopted National Ambient Air Quality Objectives and hence could be subject to the invocation of ss. 20 and 21 of the **Clean Air Act**. The Federal Government has not yet used its authority in this area.

The Sub-committee believes that ss. 20 and 21 of the **Clean Air Act** can and should be used to deal with those specific air pollution emitters which contribute significantly to the acid rain problem where provincial abatement attempts have not succeeded.

The power to adopt and enforce a Specific Emission Standard is one which the Federal Government has great reluctance to use. Its hesitation is understandable since this type of action is not necessarily consistent with good federal-provincial relations in the area of environmental protection. Because of the extraordinary nature of this power it should only be used as a last resort where other abatement strategies have not been successful. The adoption of such Specific Standards may be justifiable in circumstances where severe and irreversible environmental and economic damage is threatened by inadequately-controlled or uncontrolled emissions of air pollutants. The Sub-committee believes that acid rain is a circumstance where the Federal Government would be justified in adopting Standards for the control of specific sources of sulphur dioxide and nitrogen oxides.

The Sub-committee believes that binding Specific Emission Standards should be adopted and vigorously enforced by the Federal Government until the necessary amendments to the **Clean Air Act** are adopted by Parliament to allow binding National Emission Standards to be applied to interprovincial air pollution which results in acid rain.

Recommendation 24

The Sub-committee recommends that, where appropriate, the Federal Government invoke ss. 20 and 21 of the *Clean Air Act* which allow the Minister of the Environment to recommend Specific Emission Standards to the Cabinet which would be applicable to works, undertakings or businesses in a particular industry or region within a province which has, by federal-provincial agreement, accepted National Ambien Air Quality Objectives.

We have become convinced by the testimony we have heard and by the intense public interest in the issue of acid rain that has developed that the broadest possible public participation in attempts to resolve this problem is desirable and necessary.

The Sub-committee agrees with the following assertion made by the Department of the Environment in its June 1980 **Draft Policy for Public Consultation and Information Availability**:

> *The new approach to regulation-making is designed to encourage and better utilize the public's views and perceptions. Specifically, it is designed to: open the regulation-making process to public scrutiny; provide the public with an effective opportunity to contribute in the context of an explicit procedure; structure the various contributions in an efficient and fair manner and, where necessary, incorporate the government requirement for a Socio-Economic Impact Analysis.*

In its December 1980 Report to Parliament, the House of Commons Special Committee on Regulatory Reform recommended that government departments and agencies prepublish draft regulations wherever appropriate and seek out comments on them at the earliest possible moment.

The Canadian Environmental Law Research Foundation suggested in its Brief to the Sub-committee that there was a lack of public participation in the decision-making process.

Sections 7, 13 and 21 of the **Clean Air Act** provide for the publication of National Emission Standards and Specific Emission Standards in the Canada Gazette 60 days before they come into effect. Although s. 5 of the Act provides that the Minister shall engage in appropriate consultations in carrying out his mandate, there is no provision for pre-publication, notice and comment on draft National Ambient Air Quality Objectives and National Emission Guidelines.

Section 21.1(2)(a) of the December 1980 amendments to the **Clean Air Act** provides that there be notice in the Canada Gazette of the emission standards proposed and that reasonable opportunity be afforded to those affected thereby to make representations to the Minister of the Environment.

There is no apparent justification for the difference in notice and comment procedures, or lack thereof, when one is discussing Objectives, Standards or Guidelines — the techniques adopted to deal with air pollutants may differ in their regulatory definition but the emission problems addressed are in essence the same.

A comprehensive uniform notice and comment procedure to obtain broad public participation in the regulation-making process should be adopted based upon the provisions of the December 1980 amendments to the **Clean Air Act**, upon the Department of the Environment's **Draft Policy for Public Consultation**, upon its **Discussion Paper On Public Involvement in the Environmental Protection Service's Regulation-Making Procedure**, and upon the December 1980 Report of the House of Commons Special Committee on Regulatory Reform.

Recommendation 25

The Sub-committee recommends that an appropriate uniform notice and comment procedure be provided for in the *Clean Air Act* and that it be applicable at the earliest possible moment in the development of National Ambient Air Quality Objectives, National Emission Standards, Specific Emission Standards and National Emission Guidelines.

Enforcement and Penalties

It has often been observed that a good law badly administered is as undesirable as a bad law. This comment is especially applicable to environmental laws which often have a history of being adopted with great fanfare and then are applied indifferently, inconsistently, and hence ineffectively.

The current approach to air pollution control involves regulations requiring either the installation of specific abatement equipment or the mere compliance with emission standards by polluters through whatever technological or other means they choose. The enforcement of these controls has often been a matter of negotiation and moral suasion between the regulators and industry or, as a last resort, prosecution of the offender by the department having responsibility for protection of the environment. Examination of environmental enforcement practices and of court decisions in Canada indicates the infrequency of prosecution and the relatively small fines imposed on conviction once prosecutions have been successfully undertaken and concluded. Moreover, non-compliance or delayed compliance with environmental regulations may, in many instances, be a profitable strategy for polluting firms and, under the current enforcement system, this strategy is easy to employ.

The Sub-committee believes that governments should devote the resources required to effectively enforce existing environmental laws and regulations so that pollution generally, and in particular air pollution resulting in acid rain, is reduced. In addition, we believe that governments should actively consider and implement, where appropriate, innovative regulatory alternatives which will lead to more effective action to reduce pollution. We will now discuss some ideas for reform in this area and we urge that they be given serious consideration.

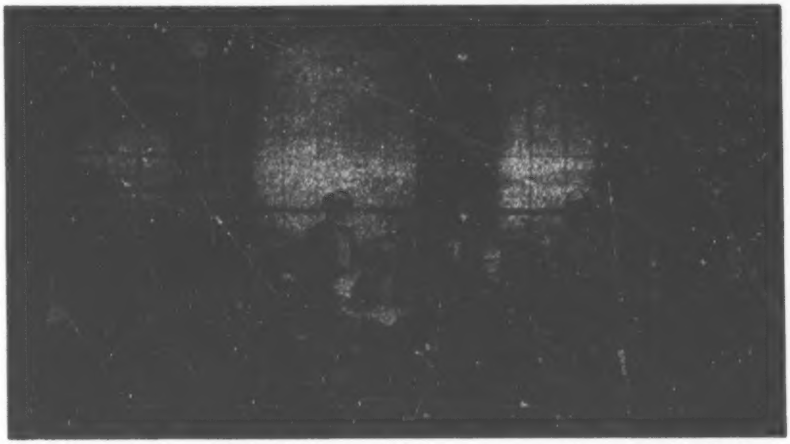
As mentioned earlier, the present regulatory scheme, wherein fines are imposed for non-compliance with air pollution control regulations, is often ineffective as a disincentive to such violations. More imaginative schemes should be developed and adopted in Canada to encourage pollution-control installations as well as to effectively penalize non-compliance. Two such variations that the Sub-committee views with favour are found in the State of Connecticut laws and in the U.S. **Clean Air Act.** Since 1973, the State of Connecticut has imposed penalties for non-compliance with emission controls. The level of these penalties is set at the estimated cost of compliance saved by the firm through its violation of the environmental regulations; the penalty charges are returned to the firm when the regulations are complied with. Thus the polluter gains no advantage by attempting to avoid pollution control regulations.

A stronger version of the Connecticut Plan has been implemented in the United States under the 1977 amendments to the **Clean Air Act.** A delayed compliance penalty is automatically imposed every three months on polluters who do not comply with emission control regulations and it is mandatory with respect to every major polluter. This penalty charge is equal to the estimated cost of compliance saved by the violator, reduced by any amount spent on compliance in the relevant three-month period. While certain exemptions from such an automatic penalty charge are allowed, usually in circumstances beyond the polluter's control, the conditions for exemption are strict and, therefore, few instances exist where the penalty is not applicable.

One of the major difficulties encountered by government agencies responsible for the enforcement of environmental legislation is the complexity of the technical evidence required and of many of the legal issues involved. At present, prosecutions are instituted in the ordinary courts. Under our present judicial system, there is very little specialization among the judges and courts themselves. It is possible for the same judge to hear family law, criminal cases and general civil matters. Consequently, very few of our judges have a high degree of expertise in environmental matters.

The complexity of environmental law issues requires a high degree of knowledge and specialization among those who have to adjudicate in this area. To leave responsibility for the application of environmental law to the ordinary courts may not necessarily lead to effective enforcement.

In addition to sufficiently high penalties, the Sub-committee believes that governments should establish environmental law tribunals which would deal exclusively with pollution matters. These tribunals should be manned by persons expert in the technical and legal aspects of environmental protection. In addition, these environmental law tribunals should be provided with sufficient professional support staff to assist them in effectively performing their adjudicative functions. These environmental law tribunals should be given exclusive jurisdiction to apply environmental law and regulations. To avoid many of the procedural and delay problems now predominant in the ordinary courts, this tribunal should adopt simple rules of procedure and evidence which would allow for environmental law prosecutions to be quickly and expeditiously processed and adjudicated upon.



Because the Fathers of Confederation did not consider environmental pollution a major issue in the nineteenth century, legislative division of jurisdiction was eventually split between federal and provincial levels of government.

In addition to the above scheme, governments should give serious consideration to providing for class action suits which would be available to Canadians to enable them to enforce environmental legislation generally, and in particular, as it applies to air pollution and acid rain-causing emissions. In its call for an environmental Bill of Rights, the Canadian Environmental Law Association stated that federal and provincial environmental protection laws should allow for class actions by which a citizen who has been aggrieved could sue on behalf of other similarly-affected citizens for damages resulting from inflicted environmental degradation.

In Quebec, the **Code of Civil Procedure** provides for a class action suit to be authorized by a court where the recourses of the class members raise identical, similar or related questions of law or fact, the facts alleged seem to justify the conclusions sought, the composition of the group makes collective action under normal joinder rules difficult or impracticable, and the member of the class attempting to bring the action is able to act effectively for the other members. The Quebec law also created a Class Action Fund which provides, on application, financial support to class action efforts which would otherwise not be undertaken. The Sub-committee urges governments to actively consider and incorporate, where appropriate, class action suits in environmental protection legislation. Serious consideration should also be given to setting up Class Action Funds which would allow such class action suits to be undertaken when the initiating individuals' financial resources would not normally permit such an undertaking.

Under s. 304 of the U.S. **Clean Air Act** any individual may institute a law suit against a polluter or a government agency for a violation of an emission standard or for non-compliance with a control program. Private prosecutions are well-established in Canada for criminal and statutory offences. In addition, some legislation provides for statutory civil remedies available to individuals affected by violations of specific statutes. Governments should give serious consideration to allowing for private prosecutions and citizen civil suits in their environmental protection legislation.

Although the Sub-committee is of the opinion that the primary responsibility for the enforcement of environmental protection legislation rests with governments, provision should be made by governments for private initiatives in the pursuit of these goals where government enforcement has proven to be incomplete, insufficiently vigorous, or nonexistent. The implementation of class action suits (supported by a funding mechanism), private prosecutions, and citizen civil suits would supplement government efforts in this area.

The government departments that administer environmental protection legislation often do not have technical and legal expertise sufficient to match that of the private sector. This is not due to the lack of talent of those who work in this area, but to the budget constraints that are often applied to environmental protection before other parts of government. In addition, the efforts of these government departments are often frustrated by delaying tactics in the courts and by the sheer volume of litigation being submitted these days to our judges.

Pending consideration of the reforms we have outlined above, it is important that the present environmental law and regulations, particularly as they relate to air pollution and acid rain, be effectively and vigorously enforced. To do this, governments should allocate enough funds to environmental protection to ensure that sufficient, highly qualified legal and technical staff are available. In addition, the courts must take the necessary steps to ensure that unnecessarily dilatory tactics are not used by litigants and that the volume of litigation is reduced. These efforts must be supported by a clear determination by the Federal and Provincial Governments to act in concert in applying environmental legislation and regulations so that acid rain-causing emissions are effectively reduced.

Recommendation 26

The Sub-committee recommends that the following elements be included in environmental protection legislation to effectively reduce pollution in general, and particularly acid rain-causing air pollution:

1) **The imposition of penalties high enough to ensure there is no benefit from saved costs of compliance in cases of non-compliance.**
2) **The creation of a tribunal which would have exclusive jurisdiction over environmental law prosecutions.**
3) **The creation of class action suits, private prosecutions and citizen civil suits.**
4) **The provision of a funding mechanism for class action suits which would otherwise not be instituted due to inadequate financial resources on the part of the initiators.**

Recommendation 27

Pending consideration and implementation of the reforms advocated in the previous recommendation, the Sub-committee recommends that effective steps be taken to apply existing environmental protection legislation, particularly as it relates to acid rain-causing air emissions. Among the steps that should be immediately taken by governments and the courts are:

1) **The provision of additional legal and technical staff to environment departments.**
2) **The acceleration of court proceedings.**
3) **The harmonization of federal and provincial enforcement of environmental protection legislation.**

Regulatory Instruments

As is mentioned elsewhere in this report, the acid rain problem can only be resolved through government intervention in the decision-making processes of firms. This can be done in a number of ways, all of which can accomplish a reduction in the level of acid rain-causing emissions. However, all of these forms of intervention are not equal in minimizing the total costs to government and industry of emission control; the relative advantages of various regulatory instruments will vary according to the specific cases considered.

One of the most commonly used regulatory instruments is an emission standard imposed on specific sources of acid rain-causing emissions. In setting such standards, policy makers give consideration to the relative importance of individual polluters, the competitive environment of the industry, the nature and success of previous abatement efforts, expected costs of abatement, etc.

Another commonly used regulatory instrument is the specification of abatement equipment to be used by current polluters. In order for this approach to be effective, the regulatory authorities must, in addition to the above mentioned considerations, possess some knowledge of pollution control technology.

In Canada, the major sources of SO_2 emissions are concentrated in two relatively homogeneous industrial groups: non-ferrous smelters and thermal power plants. Obviously, each individual case differs from the others and these differences must be considered when regulatory intervention is being considered. The homogeneity of major pollution sources, however, makes the task of specifying emission standards or abatement technologies much less difficult than it would be under different circumstances. Moreover, the Sub-committee has heard much testimony concerning methods of SO_x and NO_x abatement. These technologies are well known to polluters and governments; therefore, the inherent difficulties of the two established forms of regulatory intervention are not very serious in the case of the reduction of acid rain and its precursors.

The Sub-committee also views these regulatory instruments with favour because of the relative ease of monitoring which they imply. The abatement responsibility of major polluters can be clearly specified and their success in achieving pollution control goals will be indicative of the total Canadian success in reducing emissions.

Another approach to regulatory intervention involves instruments which attempt to approximate the workings of the market mechanism. These instruments are designed to set total emission limits for a defined group of emission sources. This group of emitters may include all polluters in the country, all polluters in a region, or all emission sources within a plant or firm. Individual polluters then have complete freedom in allocating allowable emissions among themselves as long as the total allowable emission limit is not exceeded.

This broad approach to regulatory control basically involves the establishment of a set of pollution rights by government. The total number of rights issued will determine the level of allowable emissions. If these rights can be traded only within a firm or a plant, the regulatory instrument resembles the Bubble Concept used in the United States. If these rights can be traded among firms within a geographical region, the instrument will resemble the Offsets and Credits Program under United States law.

The imposition of stringent regulatory controls is essential to an effective reduction of acid rain-causing emissions.

As the environmentalist group STOP pointed out in its testimony before the Sub-committee, the Environmental Protection Agency in the United States has recently attempted to apply these newly-developed regulatory instruments to the air pollution problem. Some evidence from the United States suggests that these instruments can be used to reduce the cost of meeting emission standards without sacrificing environmental quality.

In their recent report entitled **Reforming Regulation**, the Economic Council of Canada also urged that careful consideration be given to these and other alternative regulatory approaches. The Sub-committee therefore feels that these alternative regulatory instruments should be carefully examined and their application within the Canadian context should be given careful consideration.

Recommendation 28

The Sub-committee recommends that governments consider innovative acid rain control regulatory alternatives which have been tried with some success in other countries -- for example the Bubble Concept, Emission Offsets and Credits, etc. The Sub-committee further recommends that such regulatory alternatives should not be adopted where their effect would be to allow an overall increase in air emissions above the desired levels.

Access to Information

STOP expressed some concern, during its appearance before the Sub-committee, that the proposed access to information legislation now before Parliament (Bill C-43) does not provide adequately for access to air pollution emission data.

The Canadian Environmental Law Research Foundation affirmed in its Brief to the Sub-committee that freedom of information is essential to the effective implementation of any Canada-United States agreement on transboundary air pollution.

The Department of the Environment set out the following procedure to meet the information availability objective enunciated in its June 1980 **Draft Policy for Public Consultation and Information Availability**:

> *The Department will, on request, provide to the public:*
>
> *(i) Published departmental scientific papers, departmental*

or service publications and other regularly published departmental materials.

(ii) Routinely collected data on ambient environmental quality in either the form in which it is gathered or the form in which it will be published, as rapidly as possible but within six months from the time of analysis.

(iii) Emission and effluent data collected pursuant to federal environmental regulations, in either the raw form, or as it is prepared for publication, whether such data are collected by the province, the industry or Environment Canada, as rapidly as possible but within six months from the time of collection.

(iv) Information collected jointly through federal-provincial or Canada-international programs which would be released after agreement between the parties involved.

The Sub-committee agrees with the Department's information availability objective and commends the procedure enunciated in the **Draft Policy**.

Section 118d of the Quebec **Environment Quality Act** reads as follows:

> *Every person has the right to obtain from the environment protection services copy of any available information concerning the quantity, quality or concentration of contaminants emitted, issued, discharged or deposited by a source of contamination.*

This statutory provision recognizes that access to information is in principle and in practice essential for effective public participation in environmental monitoring, and in the policy formulation and administration procedures.

We have concluded from the evidence that we have heard and from our study of the issue that timely and adequate access to appropriate information is essential to public participation in the decision-making process in relation to the resolution of the acid rain problem.

Recommendation 29

The Sub-committee recommends that appropriate legislative provision be made to permit public access to all records and data pertaining to the discharge of contaminants into the Canadian environment.

CANADA-U.S. AGREEMENT

In the late 1970s both Canada and the United States became aware that they had a transboundary air pollution problem with both countries being emitters and recipients of pollutants.

On August 5, 1980, Canada and the United States signed a Memorandum of Intent by which a number of working groups was established to amass scientific and other data which would form the basis for negotiations toward a transboundary air pollution control agreement. Negotiations to this end began on June 23, 1981 in Washington, D.C.

The Memorandum of Intent states that both Canada and the United States will enforce existing legislation and regulations dealing with the emission of air pollutants until an agreement is signed.

In signing the Memorandum of Intent and in undertaking negotiations on transboundary air pollution, Canada and the United States demonstrated their intention to abide by established principles of international environmental law.

In a widely-quoted dictum, the Trail Smelter Arbitral Tribunal stated the applicable principle of international environmental law in its 1941 final decision as follows:

> *No state has a right to use or permit the use of its territory in such a manner as to cause injury by fumes in or to the territory of another or the persons or property therein, when the case is of serious consequence and the injury is established by clear and convincing evidence.*

Principles 21 and 22 of the 1972 Stockholm Declaration of the United Nations Conference on the Human Environment affirmed that:

Principle 21

States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.

Principle 22

States shall cooperate to develop further the international law regarding liability and compensation for the victims of pollution and other environmental damage cause by activities within the jurisdiction or control of such States to areas beyond their jurisdiction.

There is a long history of Canada-United States joint action to deal with transboundary pollution problems: the 1909 Boundary Waters Treaty, the successful arbitration of the Trail Smelter controversy in the 1930s, and the Great Lakes Water Quality Agreements of 1972 and 1978 to name only a few such efforts.

In January 1981, the United States Department of State and the Council on Environmental Quality prepared a response to the Global 2000 Report to the President released in July 1980. This document urged the United States to continue bilateral work with Canada on transboundary air pollution and to intensify legal efforts to control acid rain.

Because of the transboundary nature of the flow of emissions, we are very concerned about progress toward pollution abatement in the United States. Preliminary estimates suggest that about 3 to 4 times as much sulphur dioxide, on an annual average basis, moves across the border from the United States to Canada as in the opposite direction. A reasonable estimate of the United States contribution to Canada's sulphur-sourced acid rain is approximately one-half, with the other half originating from domestic emissions. In some sensitive areas, such as the Muskoka-Haliburton region of Ontario, the United States contribution is as high as 70 per cent. This is totally unacceptable to Canada and the United States has been so advised.

In his testimony before the Subcommittee, Dr. Ray Effer of Ontario Hydro stated that:

> *If emission reductions and rates of acid deposition are to be reduced by a sufficient amount to effect a real reversal of the trend, Canada needs to reach agreement with the United States to control those United States and Canadian emissions which contribute the major portion of the acid falling in Ontario.*

The Association of Biologists of Quebec affirmed during its appearance before the Sub-committee that:

> *Based on the actual data and future estimates put forward by our neighbours from Ontario, the Maritime provinces and the American northeastern states, that also apply to Quebec, the A.B.Q. recommends that the provincial and federal governments get together to obtain a guarantee of stability of the future air pollution emissions from the U.S.A.*

Pollution Probe stated the essence of the desired approach when it observed in its Brief to the Sub-committee that...

> *...strict pollution controls should be placed on all domestic sources of sulphur dioxide. But further there must be developed a broad public recognition of the serious impact U.S. sources will have on the Canadian environment over the next twenty years and the need for real abatement south of the border immediately.*

In a statement which has come to the Sub-committee's attention in the course of its study, Alberta's Minister of the Environment, the Honourable Jack Cookson, made the following declaration:

> *The Department strongly supports the initiatives taken by Environment Canada towards conclusion of a treaty with the United States concerning mutual Long Range Transport of Atmospheric Pollution (LRTAP). The Department has committed senior scientific staff to work with Canada/U.S.A. workgroups which were established under the Memorandum of Intent signed between Canada and the U.S.A. on August 5, 1980.*

Similar statements of support for the prompt completion of a Canada-U.S. agreement on the control and reduction of the long-range transportation of air pollutants were made in testimony and briefs before the Sub-committee by the Ontario Department of the Environment, Ontario Hydro, Pollution Probe, Grand Council Treaty No. 3, Noranda Mines Ltd., Sierra Club of Western Canada, Alberta Public Advisory Committee on the Environment, Newfoundland Department of the Environment, Prince Edward Island Natural History Society, the Ecology Action Group, and the Canadian Coalition on Acid Rain, among others.

The Economic Council of Canada in its June 1981 Report, **Reforming Regulation**, urged the Federal Government to seek an agreement with the United States "under which sulphur dioxide and other air contaminants that cause injury to the other country would be greatly reduced."

Although the Sub-committee urges the prompt negotiation and completion of a transboundary air pollution agreement between Canada and the United States, we do not believe that the improvement of Canadian legislation, regulations and enforcement should await the outcome of these talks.

The Sub-committee believes that Canadian legislation, regulations and enforcement should be improved now and not after a transboundary air pollution agreement is signed. We believe that the structures necessary under Bill C-51 to give it effect should be immediately put in place in Canada.

The Memorandum of Intent signed between Canada and the United States is a commitment from both countries not only to enter into formal treaty negotiations but to also combat acid rain immediately. The United States should be reminded periodically that we in Canada feel bound by this Memorandum and we expect a reciprocal commitment from the United States, notwithstanding a change of Administration. To put any other interpretation on this document would jeopardize future negotiations between our two countries. We have treated our obligations seriously under this document. Ontario has placed a stricter Control Order on INCO at Sudbury; Ontario Hydro has committed millions of dollars to reduce emissions from its thermal generators by 43 per cent during this decade. We have amended our federal **Clean Air Act** to allow mutual recourse between Canada and the United States. To date it appears that the United States is not approaching the problem in the same spirit. *The Sub-committee urges the United States to improve its legislation, regulations and enforcement now so that acid rain-causing emissions will be substantially reduced, and that it not await the signature of a transboundary air pollution agreement.*

Recommendation 30

The Sub-committee recommends that Canada and the United States reach an agreement on the necessary legislation and mechanisms to substantially reduce transboundary air pollution, particularly as it relates to acid rain, by the end of 1982.

Although we believe that a Canada-U.S. agreement on the long-range transportation of air pollutants should be completed by the end of 1982, we do not believe that diplomatic channels alone should be utilized to effectively deal with acid rain.

On March 12 1981 the Province of Ontario filed an intervention before the U.S. Environmental Protection Agency opposing proposed changes in SO_2 emissions to be allowed under the State Implementation Plans of six states at 20 fossil fuel-fired electrical generating plants. Ontario presented a forceful case that such increases in allowable SO_2 emissions would have a serious deleterious effect upon its environment and economy.

The Sub-committee commends the Ontario government for its vigorous intervention in the proceedings before the United States Environmental Protection Agency. We urge all interested governments, public interest groups and others to actively participate in proceedings before U.S. courts and regulatory agencies when they deal with the air pollutants which cause acid rain in Canada.

When appearing before the Sub-committee, the Canadian Coalition on Acid Rain, basing itself on a paper presented by James Moorman to a conference on the environmental consequences of energy production, urged Canadians concerned about the problem of acid rain to become involved in the U.S. political process and to consider the following points:

> *Canadians must not depend on the Canadian Government to persuade the American Government to solve the acid precipitation problem. This does*

LETTER OF SUPPORT
from the Congress of the United States

Ron Irwin, M.P.
Chairman, Sub-committee on Acid Rain
Standing Committee on Forestry and Fisheries
Parliament Buildings
Ottawa, Ontario K1A 0A6

House of Representatives
Washington, D.C. 20515
October 16, 1980

Dear Chairman Irwin and Sub-committee Members:

We are writing to commend the Sub-committee on Acid Rain for its recent journey to Washington to discuss the environmental, economic and political problems associated with acid rain.

As you are aware, the United States has taken many steps to study and ascertain solutions to the problem of acid precipitation. The Acid Rain Coordination Committee recently completed its draft plan mandated by the President in 1979. This year, Congress approved as part of the Energy Security Act legislation to provide up to $50 million over a 10-year period to study the effect of acid precipitation, and to make firm recommendations as to what can be done to eliminate or mitigate its impacts.

Working within existing law, the Environmental Protection Agency is in the process of revising regulations pertaining to stack height in order to lessen the distance pollutants travel before returning to; earth in the form of acid rain or dust.

Many of the questions about acid rain to date remain unanswered. However, we believe we must take every reasonable step to control acid rain before all the evidence is in. Review of the Clean Air Act when the 97th Congress convenes will provide an excellent forum for these concerns.

We hope the United States and Canada can achieve our respective goals of energy independence while maintaining environmental integrity. The Memorandum of Transboundary Air Pollution signed by our nations this August is a good starting point.

Again, we appreciate your efforts and pledge our support to work with the Canadian government in providing solutions to this most important environmental problem.

Sincerely,
Richard L. Ottinger, M.C.

Sam Gibbons
John D. Dingell
David R. Obey
Elizabeth Holtzman
William R. Cotter
Frederick W. Richmond
Robert Garcia
Geraldine A. Ferraro
Donald J. Pease
Robert C. McEwen
Hamilton Fish, Jr.
Jack F. Kemp
Jonathan B. Bingham
Shirley Chisholm
Vic Fazio
John L. Burton
Bob Eckhardt
John Edward Porter

James H. Scheuer
Ike Andrews
Patricia Schroeder
Robert F. Drinan
Lester L. Wolff
William D. Ford
George E. Brown, Jr.
Don Edwards
Margaret M. Heckler
Thomas L. Ashley
Donald J. Mitchell
Henry A. Waxman
Peter W. Rodino, Jr.
Ronald V. Dellums
Dante B. Fascell
Don H. Clausen
John Conyers, Jr.
Silvio O. Conte

Bill Frenzel
Arlen Erdahl
Thomas A. Daschle
William J. Hughes
Martin Olav Sabo
Howard Wolfe
Tom Harkin
Robert T. Matsui
Gladys Noon Spellman
Anthony C. Beilenson
Beryl Anthony, Jr.
Gary A. Lee
Don Bonker
David F. Emery
Berkley Bedell
Bob Edgar
Edwin B. Forsythe
Norman Y. Mineta

James L. Oberstar
Bob Carr
James M. Hanley
Morris K. Udall
James M. Shannon
Christopher J. Dodd
Joe Moakley
Stewart B. McKinney
Anthony Toby Moffet
James J. Blanchard
Barbara A. Mikulski
Jerome A. Ambro
Les AuCoin
John J. LaFalce
Joseph L. Fisher
Edward J. Markey
Doug Walgren
Ted Weiss

Michael D. Barnes
Norman D'Amours
Arlan Stangeland
Philip R. Sharp
John F. Seiberling
John J. Cavanaugh
Nicholas Mavroules
Tom Corcoran
Bill Green
Gerry E. Studds
James M. Jeffords
Harold C. Hollenbeck
Baltasar Corrada
Millicent Fenwick
Mike Lowry
John B. Anderson
Andrew Maguire

The above members of the United States Congress signed this letter of support.

The transboundary nature of the flow of pollutants necessitates an early agreement between the United States and Canada to control emissions emanating from both countries.

> *not mean at all that the Canadian Government should not try, nor that Canadians must not depend at all on the Canadian Government; what it does mean is that a powerful, organized effort in the United States by Canadian citizens is necessary if Ottawa's efforts are to succeed;*
>
> *Canadians must hire United States legal counsel to undertake legal research, the development of legal strategy, the drafting of legislation, and litigation before the various courts and administrative agencies of the United States;*
>
> *Canadian citizens must retain American lobbyists to assist Canadian approaches to the Congress, to organize approaches to the White House, and to organize approaches to the American people...*

Professor Don Munton, of the Centre for Foreign Policy Studies at Dalhousie University, offered the following advice to the Sub-committee:

> *First Cabinet Ministers, the members of this Committee, and other members of Parliament and of provincial legislatures should carry on a strong, and, as necessary, a public campaign aimed at bluntly expressing Canadian concerns and at identifying and securing potential allies within the American political system... We should not fall under the illusion that "quiet diplomacy" alone will be effective.*
>
> *My second recommendation is that interested groups in Canada and this Committee become thoroughly familiar with the issues and options potentially under negotiation, and that they put themselves in a position to resist, strenuously and publicly, if necessary, the almost inevitable pressures toward concluding an ineffective agreement...*

In a speech in Halifax on May 20, 1981, Reginald K. Groome, Chairman of the Tourism Industry Association of Canada, expressed his alarm at the potentially devastating effect unchecked acid rain would have on tourism in Canada. As a result of the grim picture painted in this speech, Mr. Groome made the following call to members of the tourism industry in Canada and the United States: "We must join forces with our U.S. counterparts and forge the stongest possible lobby to tackle both governments."

In recent months, the Minister of the Environment, the Honourable John Roberts, has addressed the issue of acid rain in clear, blunt terms through a number of public speeches in the United States. Canadian parliamentarians and public officials have begun to press the issue before Congressional committees and in the media in the United States.

These efforts at shaping public awareness and legislative opinion in the United States should be continued and, indeed, should become more assertive.

Recommendation 31

The Sub-committee recommends that governments, public interest groups, and individual Canadians in general explore and utilize all possible political, legal, administrative and media channels to ensure that acid rain-causing emissions originating in the United States are substantially reduced and that a Canada-U.S. agreement on the long-range transportation of air pollutants is signed by the end of 1982.

We have already noted in this report that there is virtually unanimous agreement among concerned observers in Canada and the United States that the acid rain problem can only be solved if there is sufficient political will, in both countries, to enact and enforce legislation to curb acid rain-causing emissions. One way to develop this political will is to obtain agreement from legislators, in both countries, that the

The problem of acid rain can only be solved if there is sufficient political will in both Canada and the United States to enact and enforce legislation designed to curb acid precipitation emissions.

problem must be tackled directly.

The Sub-committee received a suggestion from the Canadian Nature Federation that "members of the Sub-committee should be pressing on their American colleagues the great need to halt acid rain pollution for the sake of both countries." The Sub-committee agrees wholeheartedly with this suggestion. Further, we believe that Canadian legislators at all levels of government should actively pursue the issue of acid rain with their American counterparts, and with legislators from other countries, at every opportunity.

One approach, of particular interest to legislators at the federal level, is through meetings of International Parliamentary Associations. These associations provide a forum where delegates can actively lobby foreign legislators in support of policies of their own countries.

There are six International Parliamentary Associations. The most important one for Canada, with respect to acid rain, is the Canada-United States Interparliamentary Group. However, Canadian delegates to the other five groups should also vigorously promote Canada's stand on acid rain and the need for effective control strategies. The other five groups are the Inter-Parliamentary Union, the North Atlantic Assembly, the Association internationale des parlementaires de langue française (AIPLF), the Commonwealth Parliamentary Association, and the Canada-France Interparliamentary Association.

Recommendation 32

The Sub-committee recommends that the acid rain problem and its transboundary implications be publicized and discussed at appropriate meetings of International Parliamentary Associations attended by Canadian legislators. Of particular importance are the annual meetings of the Canada-United States Interparliamentary Group.

PUBLIC AWARENESS

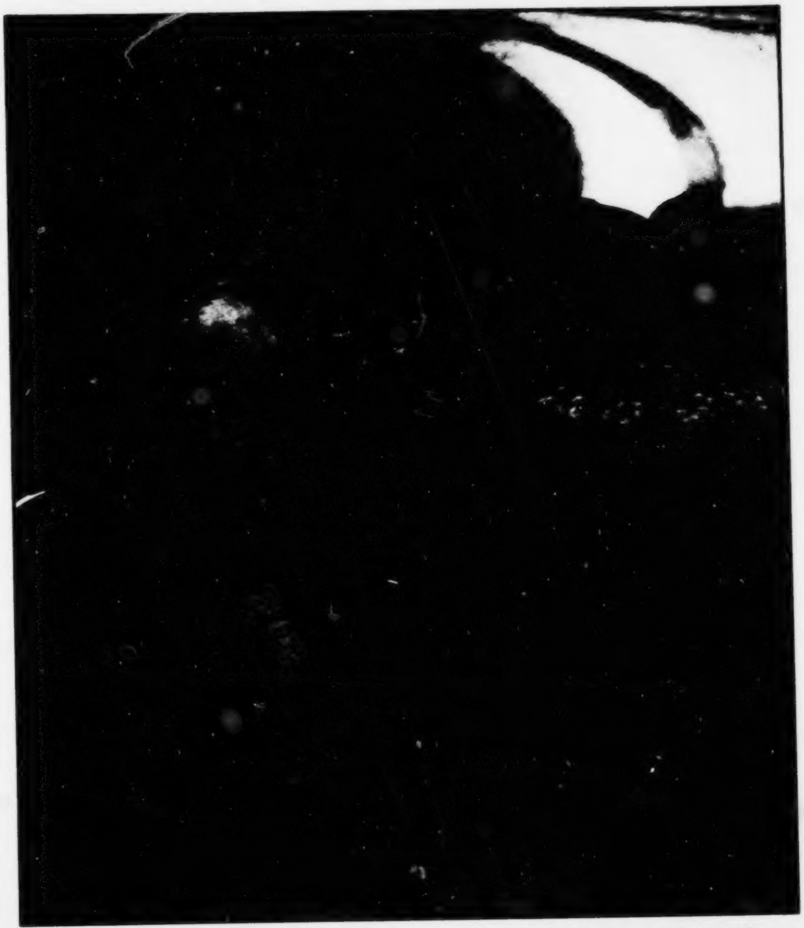
The Sub-committee has received an abundance of evidence from all parts of Canada that there is a need for increased public awareness of the seriousness of acid rain and the frightening prospects this pollution holds for the Canadian environment if it is not effectively controlled. Although Canadians are, in general, much better informed on this issue than are Americans, the Sub-committee found that there were significant differences in awareness among different regions of the country.

Public awareness of acid rain is probably greatest in Ontario. This is no doubt due to the high profile accorded the issue by the Ontario and Federal Governments. Also, various environmental activist groups such as Pollution Probe, the Federation of Ontario Naturalists, the Canadian Nature Federation, the Canadian Coalition on Acid Rain, and others, have been instrumental in bringing the issue to the attention of the public. The Sub-committee commends all of these groups for their efforts.

The Sub-committee was dismayed, however, to find that acid rain was not being effectively publicized in the Province of Quebec. This is particularly alarming because Quebec's environment is sensitive to acid rain. Most of the surface waters in Quebec north of the St. Lawrence River are highly sensitive to acidification from acid rain. Witnesses who appeared before the Sub-committee at the Montreal hearings were unanimous in their view that neither the Provincial Government nor the local news media were giving adequate publicity to the acid rain problem in that province.

The Association of Biologists of Quebec recommended to the Sub-committee that:

> *...the provincial and federal governments stress their information and awareness campaign on the acid rain effects, by establishing educational programs and distributing written and oral information that can possibly show all the aspects of the problem of acid rain in Quebec.*



An informed and aware public is the key factor in initiating the concerted political will needed to deal with the serious environmental effects of acid rain.

Similarly, the Société pour Vaincre la Pollution recommended the organization of an extensive public awareness campaign to alert the Quebec population to the dangers of acid rain.

The Sub-committee commends these organizations, and others, for bringing this issue to our attention.

It is the Sub-committee's view that the acid rain problem is not sufficiently well understood or publicized in Western Canada, with the exception of the Province of Saskatchewan. Precipitation in Western Canada is not generally acidic although the pH of precipitation in coastal areas of southern British Columbia is often below 5.0, almost ten times more acidic than normal. Across most of Western Canada, however, and particularly in the Prairies, the surface waters and the land are well-buffered and therefore resistant to acid rain. Parts of Manitoba and of northern Saskatchewan are, however, sensitive to acid rain because the Precambrian Shield extends into these regions.

The Environment Ministry of Saskatchewan, in particular, expressed concern about acid rain. That province is not itself a major source of SO_x and NO_x emissions but is located between two provinces that emit large quantities of SO_2. Alberta's natural gas processing and oil sands extraction industries are major sources of SO_2. Similarly, the large non-ferrous smelting operations in Manitoba, at Thompson and Flin Flon, emit huge amounts of SO_2. The Flin Flon operation is of particular concern to Saskatchewan because the smelter is located near the border between the two provinces.

The four Atlantic provinces indicated a growing concern for acid rain, an appreciation underscored by their geological sensitivity to acidification. The Sub-committee was concerned, however, by the narrowly provincial views expressed by witnesses from the Environment Ministries of Nova Scotia and New Brunswick. Both provinces produce substantial quantities of SO_x and NO_x, particularly from thermal power plants, but neither indicated a willingness to effect controls over those emissions.

The Sub-committee believes that there is still a need to increase public awareness of acid rain in Canada. It is our firm conviction that an informed and aroused public is essential to support the genesis of a concerted political will to deal with acid rain as a national issue.

Recommendation 33

The Sub-committee recommends that Environment Canada, in cooperation with appropriate provincial authorities, continue and expand its public awareness and information program on acid rain to alert and educate the Canadian public, particularly in those provinces and regions of Canada where the issue has not yet attained sufficient prominence.

The Sub-committee has received extensive testimony on the need to effectively publicize Canada's concerns about United States-sourced acid rain falling in Canada. At least half of the acidic precipitation falling on Canada derives from SO_x and NO_x emissions in the United States; in some sensitive areas, such as the Muskoka-Haliburton region of Ontario, the figure rises to 70 per cent.

During discussions in Washington, D.C., the Sub-committee was informed by United States officials that the subject of acid rain is only poorly perceived by the American public. Also, there is abundant evidence that many American legislators are not convinced that U.S.-sourced SO_x and NO_x emissions are having any impact on Canada; the Sub-committee is aware that many other responsible and enlightened American Congressmen are fully aware of the acid rain problem and of the trans-border effects.

Our overwhelming impression of the situation in the United States, however, is one of appalling ignorance and lack of concern for the acid rain problem and for the impact of U.S.-sourced pollution on Canada.

Reginald K. Groome, Chairman of the Tourism Industry Association of Canada, deplored, in a recent speech, the low impact acid rain has had on public opinion in the United States. He made the following plea to his industry: "We must court public opinion, especially on the American side, so that its citizens may be made aware of what is happening here because of acid rain."

The Sub-committee believes that public awareness in the United States of the acid rain problem is crucial to fostering the political will necessary for the U.S. Congress to accept the bilateral agreement on transboundary air pollution currently being developed by the Governments of Canada and the United States.

The Sub-committee recognizes that the Federal Government and some Provincial Governments have been very actively publicizing the acid rain issue in the United States and that some significant progress is being achieved. We commend these efforts. However, we believe that an even greater effort is necessary.

Recommendation 34

The Sub-committee recommends that a major public awareness and information program is necessary to generate public concern in the United States about the acid rain problem and the threat it poses to the Canadian and American environments. The present program should be continued and expanded and consideration should be given to inviting influential American media representatives to Canada so they can be apprised of the transboundary effects of U.S.-sourced air pollution.

ACID RAIN IN THE UNITED STATES

Although the Sub-committee is primarily concerned with the acid rain problem as it affects Canada, we have at no time lost sight of the fact that precipitation acidity is a global concern. It is particularly appropriate that the Sub-committee should accord special recognition to acid rain in the United States.

We are all too aware that much of Canada's acid rain problem is sourced in the immense United States industrial complex and this report unequivocably discusses that reality. The Sub-committee is equally conscious of the fact that Canada's emissions of SO_x and NO_x contribute to acid rain which falls to the south of the 49th parallel. In absolute terms, however, our American neighbours transmit far more acid rain to Canada than flows in the opposite direction.

The Sub-committee has received substantial evidence that many Americans do not recognize the existence of acidic precipitation and the potential this insidious pollutant has for environmental destruction. It is even possible that many citizens of the United States may believe that acid rain is a phenomenon which somehow confines its effects to Canada and certain European nations. It is the intention of the Sub-committee, in this section of our report, to shatter that comfortable delusion, if indeed such a delusion exists. We do this, however, with no sense of joy or satisfaction.

The earliest recorded measurement of precipitation pH in the United States was made during a rainstorm in Maine in 1939 by a scientist from the Massachusetts Institute of Technology. The reading obtained was pH 5.9; normal rainfall is considered to have a pH of about 5.6. The rain that falls in Maine today typically measures about pH 4.3.

Table 10: Top 20 Coal-Fired Power Plants in the U.S.A. Ranked According to Total SO_2 Emissions in 1979

Rank	Plant	State	Estimated SO_2 Emission Thousands of Tonnes/Year
1	Paradise	Kentucky	372.8
2	Muskingum	Ohio	340.2
3	Gavin	Ohio	339.8
4	Cumberland	Tennessee	289.7
5	Monroe	Michigan	264.9
6	Clifty Creek	Indiana	263.7
7	Gibson	Indiana	261.1
8	Baldwin	Illinois	257.9
9	Labadie	Missouri	224.0
10	Kyger Creek	Ohio	208.5
11	Bowen	Georgia	202.6
12	Conesville	Ohio	186.8
13	Mitchell	West Virginia	186.2
14	Hatfields	Pennsylvania	167.3
15	New Madrid	Missouri	164.0
16	Sammis	Ohio	160.7
17	Wansley	Georgia	159.7
18	Homer City	Pennsylvania	159.1
19	Johnsonville	Tennessee	157.0
20	Gaston EC	Alabama	154.8
			Total 4,518.1

[illegible]

The region of the continental United States most affected by acid rain is the northeast. In this densely populated and heavily industrialized area, the pH of precipitation is commonly between 4.0 and 4.5. The United States Environmental Protection Agency has reported recent studies showing that precipitation in New York City averaged a pH of 4.28; New Hampshire's Hubbard Brook Experimental Forest receives precipitation of pH 4.03; in numerous areas in the mountains of Pennsylvania, New York, and New Hampshire, pH values range from 3.98 to 4.02. Individual storms in the northeastern states frequently have pH levels between 3.0 and 4.0. Values less than 3.0 have occasionally been recorded; rain measured in the Allegheny National Forest of Pennsylvania by the U.S. National Atmospheric Deposition Program (NADP) has been measured at pH 2.32, one of the lowest levels ever recorded.

Acid precipitation has spread measurably southward and westward in the United States; the most rapid increase in acidity appears to be in the southeast. This latter observation parallels the expansion of southeastern urban and industrial activities that produce large amounts of sulphur and nitrogen emissions. In 1979, four rainstorms in North Carolina were measured at pH 3.3.

To the west of the Mississippi River, precipitation is not generally acidic, and in some areas may even be alkaline. There are exceptions, however. In Colorado, the Los Angeles Basin, the San Francisco Bay Area, in Spokane, Washington, Tucson, Arizona, and Portland, Oregon, the acidity of precipitation ranges between pH 4.0 and 5.0. A two-year study in southern California showed the average precipitation pH in Pasadena to be 3.9. The acid rain problem appears to be widespread in northern California also, and the situation is projected to deteriorate in the future.

Perhaps the most severely affected area in the continental United States is the six-million acre Adirondack State Park in northern New York State. This unique ecosystem, famed for its rugged beauty, is (in theory, at least) protected by a "forever wild" clause in the New York State constitution adopted in 1894. We use the term "in theory" advisedly. Precipitation falling in the Adirondacks today measures about pH 4.2, a level some 40 times more acid than normal. The acid is sourced in the dense clouds of sulphur and nitrogen pollutants boiling out of the gigantic industrial conurbations to the south and west of the Adirondack region.

The Adirondacks, like much of eastern Canada, is covered by the Precambrian Shield, a geological structure deficient in buffering chemicals and therefore defenseless against the effects of acid rain.

A survey of 214 lakes at higher elevations in the Adirondacks showed that more than 50 per cent are too acidic to support aquatic life: 40 years ago, before the onset of massive industrialization in the northeastern states, only 4 per cent of these lakes were without fish. In another survey by the New York State Department of Environmental Conservation of 396 lakes and ponds, 61 were found to have critical acid levels and may already be biologically destroyed; an additional 122 lakes are "endangered" and additional acid loading may destroy them.

The famous Adirondack State Park in the United States is one of the most severely affected areas in that country, with pHs measured at levels 40 times more acidic than normal.

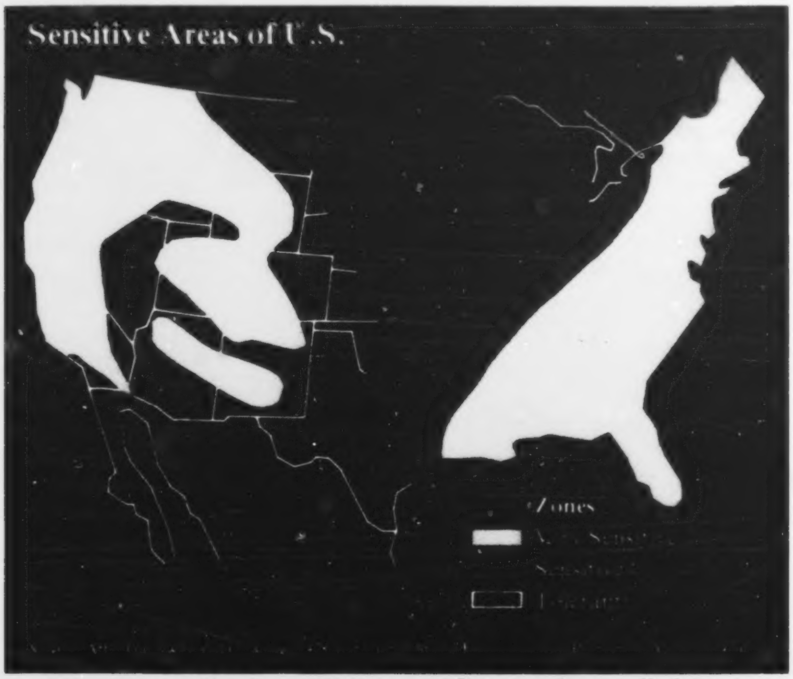
Fishless lakes are an environmental tragedy but the damage can also be translated into objective economic units. As fishermen have sought other, sweeter waters, the Adirondacks have lost millions of dollars in tourism revenues. These losses will continue and multiply in the future as more acid falls from the sky to perpetuate and extend the damage.

Another wilderness area of surpassing beauty coupled with almost absolute sensitivity to acid rain is the Boundary Waters Canoe Area-Voyageurs National Park (BWCA-VNP) of Minnesota. Here the process of lake acidication is just beginning. This region rests on acidic bedrock and is characterized by extremely soft waters, thin soils, and very sensitive terrestrial and aquatic life forms.

The State of Wisconsin, particularly the northern part, is similarly sensitive to acidic precipitation. Tourism is a $2 billion industry in northern Wisconsin. Forestry is also a major industry in the state; Wisconsin leads all states of the U.S.A. in paper production. With a continuation, and a projected increase, in acid rain, both of these enterprises are threatened.

The New England States have a high sensitivity to acid rain. In Maine, for example, measurements of selected lakes show that a majority have experienced significant decreases in pH levels and are approaching the threshold level where biological damage occurs. Maine's freshwater fisheries had an estimated net worth in 1975 of $46 million, considering the recreational value.

As the accompanying map illustrates, the entire eastern portion of the United States is highly sensitive



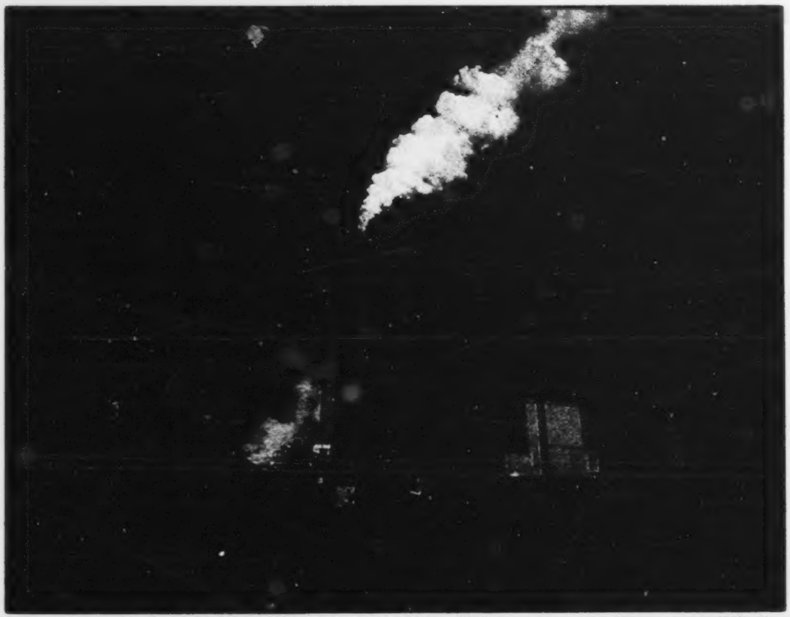
to acid rain, stretching from Maine in the north to Florida in the south. The United States E.P.A. has warned that the threshold for acidification is currently being exceeded over most of this area. The University of Florida has concluded a study showing that the environment in this state, already under attack from acidic precipitation, is likely to suffer additional stress because Florida's coal-fired electrical generating capacity is projected to increase by 250 per cent over the next decade.

Much of the east-central area of the United States is moderately sensitive to acid rain and regions of high sensitivity exist also in parts of Minnesota, Wisconsin and, farther south, in Missouri, Oklahoma and Arkansas. Almost the entire west coast is rated as highly sensitive, including a band stretching from Oregon and Washington across Montana, Idaho and Wyoming. Areas of similar sensitivity lie in Utah, Colorado, Arizona and New Mexico.

The costs of sulphur and nitrogen pollution, and of the acid rain they produce, are in a preliminary stage of investigation. Two Yale researchers, Mendelsohn and Orcutt, estimated in a 1979 study that more than 187,000 premature deaths from respiratory disease in the United States may be caused by direct inhalation of sulphates. Although the precise numbers are a subject of some controversy, there is no basic disagreement that sulphate air pollution is detrimental to human health.

Forestry is almost as important to the United States as it is to Canada. Forest ecosystems in the eastern and northwestern United States and in Minnesota and Wisconsin are highly sensitive to acid rain. One estimate for damage to American forests from air pollution comes to $250 million annually. If, as many scientists suggest, acid rain irreversibly damages the forest ecosystem, the eventual costs will be much higher and will increase yearly.

The effects of air pollution and acid rain on man-made materials are well known and the costs are estimated to be enormous. The President's Council on Environmental Quality, in a 1979 study, estimated that the annual cost in the United States of architectural damage alone was in excess of $2 billion. When automobiles, statuary and monuments, and other structures are



The many coal fired plants that line the Ohio Valley are not only responsible for much of the environmental pollution in the U.S., but they are believed to be among the chief sources of Ontario's acid rain problem.

included, the costs of damage become almost incalculable.

The Sub-committee urges responsible citizens and government officials in the United States to consider very carefully the manifold implications of acid rain. We are aware of the fact that all of the necessary data on acid rain have not yet been gathered and that much more research needs to be done to satisfactorily define the extent of the problem. *Nonetheless, the Sub-committee is convinced that our vast and numerous industrial activities are, in many areas, overtaxing the capacity of the North American environment to absorb the wastes we are producing.*

Canada and the United States now have entered into negotiations to develop an agreement on the long-range transport of air pollutants. These negotiations must be conducted in a spirit of cooperation and enlightened self-interest. *Canadians and Americans are, in a real sense, custodians of the North American environment. We have a moral obligation, underscored by a hard practicality, to protect our joint heritage, for ourselves and for future generations.*

ECONOMIC ASPECTS OF ACID RAIN

As public awareness has recently become focused on the acid rain problem, it has become increasingly obvious that the environment is a scarce natural resource. And as the acid rain issue has further pointed out, in some respects the environment may be a *non-renewable* natural resource.

For these reasons, it is necessary to ensure that the environment is managed properly. At present this is not happening. The environment belongs to everyone; but in effect this means that the environment belongs to no one and as a result no one ensures that the quality of the environment is maintained. Acid rain is currently despoiling the environment because firms, operating in their own best interests, find it profitable to pollute, and because, collectively, society has failed to devise a mechanism which protects this common heritage.

Before proceeding to enumerate the costs imposed by acid rain and to consider what it might cost to clean up this form of pollution, it is useful to discuss the reasons why this problem exists. This discussion will be useful also in demonstrating why some governments are lax in actively resolving the problem.

All economic activity produces waste which somehow must be disposed of. Waste may be disposed of in a manner which generates pollution (and costs associated with this pollution). Alternatively, waste may be disposed of in a manner which generates little or no pollution, or in a manner which generates a less noxious or less damaging form of pollution. This last option also generates costs, but these costs are paid for by the firm instead of by society as a whole, of which the firm is but a small part. As a result, any firm which tries to reduce its waste disposal costs will prefer to pollute and thus transfer the costs to society at large.

From the point of view of the firm, the environment is a factor of production just as land, labour and capital are productive factors. However, the environment is free whereas the other factors have positive prices. As a result the firm will substitute the use of the environment for the other inputs whenever possible in order to minimize its waste disposal costs. In other words, a firm can reduce its own waste disposal costs, which is equivalent to maximizing its profit, by polluting the environment.

In trying to minimize their own waste disposal costs, firms use the environment as a *free garbage dump. However the environment is only free to the polluter — society as a whole, and in particular certain segments of society, must bear the costs of this environmental degradation.* This point is made clearly in the brief submitted to the Sub-committee by the Waterloo Public Interest Research Group. As that brief pointed out:

> *The use of the environment as a free garbage dump, on closer examination reveals it is only free in the eyes of the polluter. The costs of pollution are being paid by the tourist operators who are losing their jobs, by reduced property values, decreased human health and, more importantly, the destruction of the most important resource we have, the fragile environment on which we depend.*

It is clear that the costs of producing certain products — such as electricity from fossil fuels, or various metals requiring the smelting of sulphide ores — are not borne solely by the producers or consumers of these products. Others, who are simply bystanders, are also forced to pay some of these costs in the form of environmental damage.

No one can be excluded from using the environment. As a result, ownership is impossible and the environment is treated as a free good. This lack of property rights, which are usually associated with private ownership, contributes to the overuse of the environment and to forms of pollution such as acid rain. The market cannot, therefore, properly allocate the use of the environment. This function must be performed collectively by the government which is elected to act on behalf of the total society.

Acid rain is produced because firms, operating in their own best interests, function within an institutional framework which cannot effectively manage the environment. Under some circumstances, the same argument can be made with respect to political jurisdictions. Since acid rain is associated with the long-range transport of air pollutants, emissions originating in one political jurisdiction can be deposited in another jurisdiction. Thus any government which operates in the best interests of its own citizens will tend to do little about controlling emissions which fall in, and cause damage to, other provinces, states or countries. *Just as acid rain allows firms to impose external costs on third parties, acid rain allows one political jurisdiction to impose such costs on other jurisdictions. In this respect governments behave like private firms.*

The Costs of Acid Rain

It is almost a truism to state that everyone is eventually affected by acid rain. Directly or indirectly, the external costs of acid rain are passed on to almost everyone but the costs are not borne evenly or equitably by all Canadians. The pattern of costs imposed by acid rain depends upon the geographical pattern of depositions across Canada, differences in buffering capacity, and differences in the economic activities in which individuals engage.

In major tourist areas such as the famed Haliburton-Muskoka area of Ontario, annual tourist industry losses due to acid rain could amount to $230 million.

The relationship between acid rain, the pH level of water systems, and fish populations is now well documented. Tourism is an important industry in Canada and in some areas the local fishery forms the basis of this industry. Northern Ontario is just such an area where a major source of income is threatened by acid rain. Here tourism is worth about $1 billion annually and the value of the fishery is about $600 million. The total annual loss due to acid rain could reach as high as $230 million annually.

Such large economic losses can also be expected in Quebec because that province's waters are also susceptible to acid rain damage. However, the sport fishery is not as important a contribution to tourism revenues in Quebec as in Ontario. Based on a 1975 survey, total annual expenditures by anglers exceeded $560 million in Ontario while the expenditures in Quebec amounted to $90 million.

The salmon fishery in Atlantic Canada has been damaged by the acidification of spawning waters. In Nova Scotia, nine rivers can no longer support salmon runs due to low pH levels. This has been estimated to represent an annual loss to the local economy in excess of $300,000.

Tourism (and fishing) is but one example of how acid rain imposes costs on certain sectors of the economy. In fact, however, Canada heavily depends upon a number of economic activities which may prove to be particularly susceptible to acid rain damage.

The forestry industry, in its broadest sense, accounts for a significant part of Canadian manufacturing activity. In 1978, the Canadian wood industries and pulp and paper industries employed 197,000 workers, or 15% of total manufacturing employment. Total value of shipments amounted to $17.67 billion. It is thus clear that Canada's forest resources are the basis for a significant proportion of domestic economic activity.

At present, no rigorous estimates exist of damage to Canadian forestry by acid rain. The scientific evidence on acid rain damage is still being compiled and suggests that the main danger lies in cumulative acid loadings leading to acidification of the soil. The need for more research in this area is obvious — the Canadian forests are such a valuable resource that their protection is vital. In the United States, where the forest sector is much less important to the total economy, acid rain is estimated to cause annual damage in the hundreds of million dollars. It is therefore apparent that the potential for damage to Canadian forests is very high since a large part of these forestry resources lie in the most sensitive areas of Ontario and Quebec.

Agriculture is another area which may be susceptible to acid rain damage and which constitutes a significant sector of the Canadian economy. No data on Canadian damage are available; however, American estimates of reduced agricultural damage due to the attainment of secondary air quality standards in 1978 are $1.78 billion (1980 U.S. dollars). These estimates are for nineteen food and fibre crops. However, it should be noted that acid rain is not the direct cause of these damages. Rather, it is acid rain precursors which affect crops through increases in the levels of ozone, a pollutant which, like acid rain, is subject to long-range transport.

Acid rain also adversely affects a number of materials. Studies exist which suggest that the annual damage to building materials in Canada is at least $285 million. This is undoubtedly a serious understatement of the total materials damage from acid rain. Metal corrosion is also caused by this form of pollution and if, as the International Joint Commission suggests, 50% of automobile corrosion may be caused by acid rain, then the total materials damage far exceeds the above figure.

American data on materials damage indicate that meeting secondary air quality standards in 1978 reduced the value of this damage by $3.95 billion. Sulphur dioxide depositions and changes in ozone levels account for 97% of this damage, although the individual contribution of each element cannot be determined.

The most contentious cost of acid rain deals with human health effects. Where such costs are suggested, acid rain is only an indirect cause. These indirect health costs are due to the leaching of heavy metals into drinking water or due to the existence of sulphate particles in the atmosphere. Using available studies, it is estimated that a 50% reduction in INCO's emissions could lead to reduced health costs of up to $500 million per year.

The available American data also point out the possibility of significant health damage due to acid rain and acid rain precursors. Reduced health costs are estimated to represent 80% of total benefits due to improved air quality. These benefits are directly attributed to reductions in suspended particles and SO_2.

The American data also point to a wide variation in estimates of the cost of damage to health. This is due to variations in the value placed on human life as well as differences of scientific opinion with respect to actual damage to health. Thus the estimated health benefits due to a 20% reduction in air pollution in the United States range from $3 billion to $43 billion per year.

These figures should not be considered as a rigorous inventory of acid rain costs for application to Canada. Many areas of damage are not included because necessary information is often lacking. Further, as the estimates on health damages demonstrate, the scientific data upon which such estimates

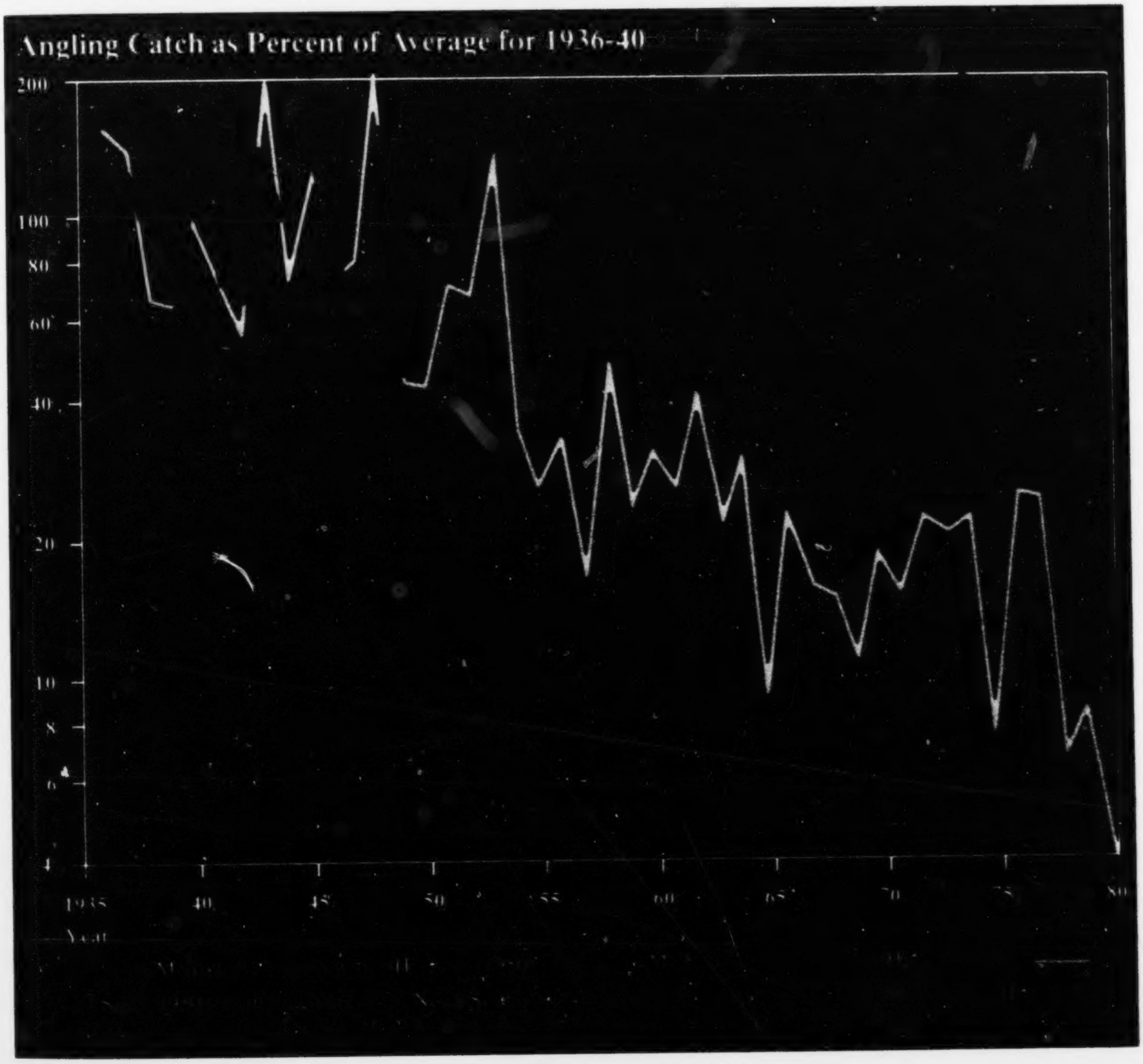

Angling Catch as Percent of Average for 1936-40

Table 11: Annual Costs of SO_2 Emissions in Europe

Category of Damage	Level of Emissions (in million tonnes per year)		
	24.39	19.63	12.68
Mortality	N.A.	N.A.	N.A.
Materials	[illegible]	[illegible]	18,858
Crops	424	[illegible]	210
Aquatic	[illegible]	[illegible]	4
Total	20,283	19,705	19,072

would be based are also not readily available. In addition, these figures do not take into account the alternative uses to which certain resources can be put. However they do indicate some of the areas where acid rain can cause significant damage and therefore give some indication as to the distribution of this damage.

One attempt at just such a rigorous study of acid rain costs was recently completed by the Organization for Economic Co-operation and Development. This study is based on European data for emission trends and damage estimates. These damage estimates are generally the result of experiments based on specific crops or materials which are then applied to the broad categories under consideration. The above table summarizes the pattern of these costs in relation to different levels of $S0_2$ emissions and is based upon 1974 European meteorological conditions.

As the table points out, a large proportion of total damage costs is due to material corrosion or expenditures to prevent such corrosion. As these data also suggest, a 50% reduction in emissions will not significantly reduce this corrosion cost. The damage to crops and aquatic life represents a much smaller proportion of total damages. However crop and aquatic damages are much more sensitive to emission levels than are material damages. A 50% reduction in emissions is estimated to lead to a 50% reduction in crop damage and an 89% reduction in aquatic damage.

Health cost figures are not provided in the format used in the above table. However, the report does estimate that a reduction in annual emissions from 24.39 million tonnes to 19.63 million tonnes will reduce health costs in Europe by $280 million — $6,985 million. A reduction from 24.39 million tonnes to 12.68 million tonnes is estimated to reduce health care costs by $573 million — $14,330 million. As the Canadian figures provided earlier pointed out, and as confirmed by the O.E.C.D. study and the American data, the greatest acid rain damage may well be to human health. It should also be mentioned that the O.E.C.D. study did not attempt to place any value on human life, and as a result, the above figures do not include the cost of increased mortality.

These O.E.C.D. figures also suggest that health damage is very sensitive to changes in total SO_2 emissions. Therefore, increased abatement may generate significant benefits in this area.

The European data cannot be applied to the Canadian case without some modifications. Canada relies more heavily on forestry, agriculture and tourism based on aquatic resources than does Europe, so these categories should be relatively more important here. The pattern of urbanization also differs between Canada and Europe as do weather patterns. However the evidence produced does suggest that the impact of acid rain extends far beyond simply killing off lakes and eliminating some fish populations — it can have serious effects on materials and health damage. By

Many of Canada's valuable forest resources are located in the most sensitive areas of Ontario and Quebec.

Priceless antiquities are irreparably damaged by acid rain.

accounting for the different sizes of Europe and Canada, these two forms of damage may still cost Canada billions of dollars per year.

The O.E.C.D. figures indicate that reduced emissions of SO_2 can generate significant benefits in the form of reduced damages due to acid rain or its precursors. A 20% reduction in emissions is expected to generate total benefits of from $858 million to $7.5 billion per year while a 50% reduction in emissions should generate $1.78 billion to $15.54 billion in annual benefits. The European figures point out, first of all, that acid rain can impose very significant levels of cost and secondly that the benefits of control can exceed the costs of control. ***Thus a "do nothing" policy can be more expensive than a policy of actively controlling SO_2 emissions.***

Costs of Controlling Sulphur Dioxide Emissions

There are two major sources of relatively large-scale sulphur dioxide emissions in Canada: non-ferrous smelters and thermal power plants which burn large quantities of fossil fuels. This latter category of polluter represents the largest single group of SO_x emitters in the U.S. while in Canada non-ferrous smelters represent the largest group of SO_x emitters. It is also within these two categories that some generalizations can be made with respect to the costs of emissions abatement.

Several studies exist which estimate the cost of emission control technologies to the non-ferrous smelting industry and thermal power generation. These estimates should be considered as indicative of broad ranges of costs because certain items are excluded and because some of the assumptions upon which they are based have proved to be unrealistic. In addition, due to the different sources of the cost estimates, the methodologies upon which they are based differ and comparisons must therefore be made with caution.

Non-Ferrous Smelting

SO_2 emissions can be reduced by removing some sulphur from the ore (pyrrhotite rejection) as well as by SO_2 recovery from flue gases, mainly in the form of sulphuric acid. This latter method is the most common form of emissions abatement as well as the most promising for future control due to the possibility of marketing the by-product.

In 1974-75 INCO proposed a reduction of emissions from 3,266 tonnes per day (t.p.d.) to 1,360 t.p.d. at its Sudbury operations by using an oxygen flash smelter process and associated acid plants. This proposal was later withdrawn by INCO. In a report entitled **Sulphur Dioxide Regulation and the Canadian Non-Ferrous Metals Industry**, Brian Felske and Associates updated the cost estimates of this proposal to 1980 values. The estimated capital cost of the proposal is $325 million. The annual costs of SO_2 control were then estimated on the basis of certain assumptions. With an interest rate of 15%, a lifespan of 15 years for abatement capital, and an assumed loss on sulphuric acid of $8.82 per tonne of acid, the annual

Recovery of elemental sulphur from natural gas processing plants, for various marketing uses, has proven successful in controlling SO_2 emissions.

Table 12: SO_2 Abatement Costs for the Hudson Bay Mining and Smelting Company Smelter at Flin Flon, Manitoba

	Case A (28% abatement)	Case B (62% abatement)	Case C (93% abatement)
Annual Emissions (tonnes)	178,704	93,446	17,374
Total Capital Costs	27,048,210	48,187,610	61,683,380
Annual Capital Cost	3,990,000	7,930,000	[illegible]
Annual Operating Cost	648,367	683,271	1,386,721
Total Annual Cost	4,638,367	8,613,271	10,196,721
Total Cost per tonne of sulphur removed (in 1980 $)	66.70 73.70	49.50 54.70	44.20 48.85

[illegible]

cost of SO_2 control is $45.57 million ($65.53 per tonne of sulphur removed). If the resultant acid is sold at $5.51 per tonne to a fertilizer plant (based on the Cargill phosphate deposits, for example), the annual costs fall to $40.57 million ($58.35 per tonne of sulphur). If various tax reductions are made available, the after-tax cost to INCO falls to $18.02 million per year ($25.92 per tonne of sulphur). These figures also take into account the energy savings due to this new process. Over twenty years, these savings should exceed $280 million. *These figures indicate that SO_2 controls would not constitute a significant economic burden for INCO.*

Depending upon which of Felske's scenarios for the nickel industry are considered, the abatement cost is between 3¢ and 15¢ per pound of nickel. This compares with an average price of $2.84 which INCO received in 1979.

Environment Canada estimated the cost to INCO of reducing emissions to 900 t.p.d. The Department's estimate assumed the installation of an oxygen flash smelter 25 per cent smaller than that included in Felske's estimate because the Department included the use of pyrrohtite rejection in their estimate. Total capital costs were estimated at $430 million with total annual operating costs of $60.1 million ($90.72 per tonne of sulphur removed). This represents an added cost per pound of nickel of 18¢-23¢.

As with the Felske estimates, these figures may understate the costs of SO_2 control. If the sulphuric acid cannot be sold, it must be neutralized and disposed of. According to Environment Canada, this would increase the cost of control by $33.28 per tonne of sulphur removed. The cost of SO_2 control would increase also if elemental sulphur were produced instead of sulphuric acid.

A similar type of analysis was performed by Felske for the Hudson Bay Mining and Smelting (HBMS) operation at Flin Flon, Manitoba. Current emissions are 680 t.p.d. of sulphur oxides. Felske considered three cases: A) 28% emissions abatement; B) 62% abatement; and C) 93% abatement. Assuming an 8% real return on capital and a 15 year lifespan for the control equipment, the costs of abatement have been summarized in Table 12.

As with the INCO estimates, these costs probably understate true costs. It would be much more difficult to market acid produced in Flin Flon due to high transportation costs; therefore, acid neutralization costs would probably be incurred. On the basis of these figures, it appears to be less expensive to control emissions at the HBMS facility than at INCO's operations. However if the INCO sulphuric acid can be marketed while the HBMS acid must be neutralized, this relative advantage is reversed.

The Province of Quebec has produced a series of studies on the estimated cost of SO_2 abatement at the Noranda copper smelter in Rouyn-Noranda. According to these studies the cost of abatement is significantly higher than for HBMS. A 70% abatement of emissions is estimated to entail $33 million in annual capital costs for Noranda as opposed to $8.8 million in annual capital costs for 90% abatement at HBMS.

This difference in estimated costs may be due to different assumptions behind the two studies. However, it may also point out the dangers of generalizing estimates from one facility to the entire industry. Emissions control at some facilities might entail relatively simple additions to the plant while at other facilities a similar abatement might involve completely revamped production facilities and significant changes in production processes.

In their testimony before the Subcommittee, Noranda officials provided estimates of abatement costs for the Horne smelter at Rouyn. The capital cost of retaining 40% of SO_2 emissions would be approximately $78 million, while 70% retention would entail a capital cost of $186 million. The total increase in annual costs due to SO_2 abatement is expected to be $27 million for 40% abatement and $57 million for 70% abatement.

Some estimates of abatement costs are also provided by the *U.S.-Canada Work Group on* Transboundary Air Pollution in its Interim Report. According to the report, a 57% reduction in SO_2 emissions can be achieved by eastern Canadian non-ferrous smelters which would require major changes at four smelters and minor changes at two others. Total estimated capital cost would be $1.1 billion. Annual costs would increase by $120 to $150 million which represents increased costs of 15¢ to 20¢ per pound of nickel and 5¢ to 8¢ per pound of copper. This represents a cost per tonne of sulphur removed of $86.45 to $108.07 in 1980 dollars.

An Environment Canada report entitled **A Study of Sulphur Containment Technology in the Non-Ferrous Metallurgical Industry** estimates an average cost of sulphur recovery of $103 to $106 per tonne. These figures are within the upper range of the Canada-U.S. Work Group figures, although the basis for the difference is not known.

On the basis of the data presented here, it appears that the cost of sulphur recovery is significantly lower for INCO and HBMS than for most other plants in the non-ferrous smelting sector. It appears also that a significant amount of SO_2 can be recovered at costs below $165 per tonne even if the by-product cannot be successfully marketed. This represents a significantly lower abatement cost than for thermal power plants, as the next section will demonstrate.

Thermal Power Plants

As with non-ferrous smelters, there are two broad methods of reducing SO_2 emissions from thermal power plants. The level of sulphur in the input (in this case fossil fuel) can be reduced by using a naturally low-sulphur input or by cleaning the fuel; the second method is to recover sulphur from the flue gas using a variety of scrubbing techniques. The cost of removing a unit of sulphur is generally lower for high-sulphur fuels than for cleaner fuels, but since the total amount of sulphur to be removed is higher, it is not obvious whether total abatement costs rise or fall with increased sulphur content of the fuel.

Physical coal cleaning (or washing) involves a process whereby sulphur is removed from coal by taking advantage of the different specific gravities of sulphur and carbon. The coal is crushed and shaken. The heavier particles which settle to the bottom tend to be concentrated with sulphur. In addition to crushing, washing or mineral concentration methods can be used to further separate the sulphur-laden particles and the relatively clean coal.

Coal can also be cleaned using various chemical methods, wherein the sulphur is leached out of the coal using chemical additives. Another method is to dissolve the coal and reconstitute it into various solids. The resulting coal solid will have most of the properties of ordinary coal except that the amount of polluting components will have been reduced.

Scrubbing is a technique in which sulphur is removed from the flue gas rather than from the input fuel. The flue gas is passed through some reactant which combines with the SO_2 to form a removable product. If the injected spray is dry lime, then the waste product will be in dry form. If the injected slurry is limestone, then the result will be a wet sludge. Scrubbing techniques also exist which allow for the eventual recovery of the SO_2 stream. These techniques utilize a variety of reactants such as a sodium sulphite solution or spray, or a magnesium oxide slurry. The result will be an intermediate product which must be further processed to evolve a rich stream of SO_2, or in the case of the sodium sulphite spray, a hydrogen sulphide gas stream which can be converted to elemental sulphur.

In its Interim Report, the U.S.-Canada Work Group on Transboundary Air Pollution ranked a variety of SO_2 control methods according to their sulphur recovery efficiencies and costs. With high-sulphur coal (3.5% sulphur content), physical coal cleaning is an efficient control technique if the required emissions abatement level is less than 30%. The cost per tonne of sulphur removed is about $485. Limestone scrubbing has a similar cost per tonne of sulphur recovered but has a removal efficiency of up to 85%. Thus, if a relatively high degree of sulphur recovery is required, physical coal cleaning is not an acceptable procedure.

It is claimed that a recovery efficiency of 60% - 70% can be achieved through chemical coal cleaning. However, the cost is between $550 and $970 per tonne of sulphur removed, making it an unattractive option when compared with limestone scrubbing. In addition, this process has not been applied commercially so the estimated costs are probably less reliable than for limestone scrubbing.

The cost per tonne of reducing sulphur emissions increases significantly when low-sulphur coal (0.7% sulphur content) is used as a fuel. In this case, it costs $4,145 to remove one tonne of sulphur using physical coal cleaning and $1,962 to remove one tonne of sulphur using limestone scrubbing. As a result, *flue gas desulphurization using limestone scrubbing has a clear cost advantage over physical coal cleaning.*

This section does not describe all the possible methods of reducing SO_2 emissions from coal-fired power plants, although they do represent techniques that are currently used. To the extent that these figures are valid, they do demonstrate that *the per unit costs of reducing SO_2 emissions are significantly lower for* *non-ferrous smelters than for power plants.*

A similar conclusion may be drawn from cost estimates for reducing SO_2 emissions in oil-fired power plants. A recent O.E.C.D. publication, entitled **The Costs and Benefits of Sulphur Oxide Control**, estimated the costs of reducing SO_2 emissions in European O.E.C.D. countries. The major control technology examined in this study was the desulphurization of residual fuel oil. Lesser alternatives considered were the installation of flue gas desulphurization equipment in new power plants and coal desulphurization as utilized in the United Kingdom. These latter technologies involved estimated costs of $400 (1980 U.S. dollars) per tonne of sulphur removed.

The estimated costs for desulphurization of fuel oil to a 0.5% sulphur content were $300 to $400 per tonne of sulphur removed for high-sulphur oil and $500 for medium-sulphur oil. On this basis, a number of scenarios were evaluated against a Base Case estimate of 1985 SO_2 emissions. The result of this experiment is summarized in the following table.

The extent to which these figures are valid for Canada or for the U.S.A. is not known. However, the above figures are not out of line with Canadian estimates of SO_2 control costs for coal-fired power plants. In this respect, the O.E.C.D. estimates confirm the conclusion that the control of sulphur emissions from fossil fuel-burning power plants is more expensive than the control of emissions from non-ferrous smelters.

Recycling

Recycling used materials is a practice which is commendable in many ways — it can save raw materials; it also reduces the consumption of natural resources through energy savings. Another favourable feature of recycling used materials (especially metals) is the reduction in polluting emissions which results from this practice. Such a reduction in emissions is due to two factors: the energy required to produce one tonne of final product is reduced significantly, thereby reducing emissions due to energy generation; and the feedstock is one which is no longer laden with polluting materials, as in the case of a sulphide ore.

It is this potential for reducing airborne pollutants which makes recycling an attractive option. This interesting feature can be exemplified by considering the role of recycling in the Canadian copper industry.

According to the Canadian Association of Recycling Industries, just over 360,000 tonnes of copper were recycled in Canada in 1980. In the same year, Canada's copper industry produced 708,400 tonnes of copper. As the figures point out, at least one-third of Canada's total 1980 copper supply came from recycled material.

The estimated savings generated by producing copper from scrap rather than ores are 68.8 per cent for energy use and 98.5 per cent for total air pollution effluents. This latter figure is not disaggregated for the various types of air pollutants. However, if it also applies to sulphur dioxide emissions, then a rough estimate of copper recycling's impact on acid rain-causing emissions can be obtained.

The production of one tonne of smelted copper in Canada generates, on average, 2.70 tonnes of SO_2 emissions. This figure is a weighted average of Canadian smelters which handle only copper as well as those which smelt a significant amount of copper in addition to other metals such as nickel. Of course this ratio can vary significantly between smelters — some have abatement programs in place while others do not; and the characteristics of the ores used also vary from smelter to smelter. However, if the SO_2/copper ratio of 2.70 is indicative of the ratio which results from the smelting of another 360,000 tonnes of copper, then recycling copper has potentially reduced Canada's SO_2 emissions by just under one million tonnes per year.

These figures are obviously rough estimates. In the absence of this recycled copper, it is not known to

Table 13: O.E.C.D. Estimates of Annual European SO_2 Control Costs

Scenario	Actual Emissions (10^6 tonnes)	Emissions Reduction (10^6 tonnes)	Emissions Change from Base Case	Average Cost Per Tonne of Sulphur Removed (1980 Can. $)	Total Cost of Abatement (in millions of 1980 Can. $)
Base Case	[illegible]				
I	[illegible]	0.85	[illegible]	445	376
II	[illegible]	[illegible]	[illegible]	410	2,272
III	[illegible]	[illegible]	[illegible]	451	5,759

what extent smelter production would increase and similarly it is not known to which smelters this increased demand would be directed. However, *it is clear that the current practice of large-scale copper recycling has allowed Canada to maintain a significantly lower level of noxious emissions such as SO_2 than otherwise would be the case.*

Sharing the Costs of Abatement

As the figures presented earlier suggest, the abatement of acid rain-causing emissions is a very expensive procedure. A 50 per cent reduction in SO_2 emissions by Canadian non-ferrous smelters would increase total annual smelter costs by $100 million—$150 million dollars. An additional 50% reduction in SO_2 emissions by Canadian thermal power plants would generate annual cost increases of $169 million. In addition, a significant reduction in SO_2 emissions may require the use of certain technologies which are both highly capital intensive and risky.

In providing financial assistance to firms, the economic impact of implementing SO_2 controls on specific localities in Canada can be moderated. Mr. George Lund, Chairman of the Regional Municipality of Sudbury, stressed the need for fairness when dealing with polluters and the communities in which they are located. In his submission to the Sub-committee, he stated:

> *There must be a reduction in sulphur and nitrogen oxide emissions, but those reductions must be achieved uniformly and equitably. The cost of the reductions must be equitably borne by all industry and utilities, not by one company or one community.*

The tax system is one method by which financial assistance can be provided to firms. In its brief to the Sub-committee in Montreal, the Accelerated Capital Cost Allowance Program was suggested by STOP as one instrument by which such assistance can be provided.

The Accelerated Capital Cost Allowance Program, as applied to pollution abatement equipment, allows firms to write off the total cost of such equipment over two years. This accelerated depreciation generates benefits to firms over and above those provided by standard capital cost allowances.

The availability of such fast write-offs for pollution control devices was initially intended by the Federal Government to be a temporary measure. The Sub-committee feels that this program should be made permanent. Moreover, this program is not currently applied universally to all production facilities. The fast write-off applies only to control devices installed in plants which were in operation or under construction prior to 1974. Thus, the Sub-committee feels that there is room for extending the scope of this program.

Recommendation 35

The Sub-committee recommends that Accelerated Capital Cost Allowances continue to be granted for air pollution control devices and that these allowances be extended to new plants.

The Sub-committee recognizes that the imposition of emission controls can cause financial harm to firms which operate in a competitive environment, thereby justifying a certain amount of public assistance. In addition, current polluters operate within an institutional framework which has not discouraged such emissions in the past. In fact, part of the acid rain problem is due to the use of high smokestacks, the use of which was encouraged by governments to improve ambient air quality around the source of the pollution. The recognition of these facts by the Sub-committee does not excuse firms from their responsibilities for emissions abatement; it simply admits to some responsibility on the part of society at large to assist in achieving the desired level of pollution abatement.

The cost of achieving a specific emission standard is significantly lower for new production facilities than for older plants. In some cases, older facilities cannot accommodate the required control equipment without a significant rebuilding of a plant. Future production facilities will be built within an atmosphere of environmental concern as well as in a time when the causes and effects of acid rain will be well known. As a result, the Sub-committee feels that old production facilities should be treated differently from future plants. In the latter case the primary responsibility for emissions control, however, should rest with the polluter.

Recommendation 36

The Sub-committee recommends that the polluter-pay principle apply to the cost of installing abatement equipment in any future production facilities whose operations have the potential to emit oxides of sulphur or nitrogen.

This recommendation does not prevent the future production facilities from receiving government benefits designed for all firms which abate emissions. Thus, Accelerated Capital Cost Allowances would be available to all firms. Similarly, government benefits such as aid in marketing sulphur products, or the development of pollution control technology financed in whole or in part with government funds would be available to all firms. However, *the Sub-committee feels that production facilities built in the future should carry the primary burden of*

One of the more promising solutions to the control of sulphur emissions is the recovery of SO_2 *from the flue gases, mainly in the form of sulphuric acid, which can be used in the production of phosphate fertilizer.*

ensuring their own environmental cleanliness.

The Sub-committee accepts the philosophy of shared responsibility on the part of industry and society as a whole toward pollution control. On the other hand, such a sharing of costs should not be used as an excuse by industry to forego its own duty. This sentiment is best expressed by Local 6500 of the United Steelworkers of America who stated, in their brief before the Sub-committee:

> *As citizens, we understand the need to protect our delicate environment. We expect and accept the costs that will occur if we wish to protect our environment from our modern lifestyle. We now ask, is industry prepared to accept its responsibility in dealing with this long-term and costly problem?*

The evidence suggests that the best emission-control technology currently available for non-ferrous smelters will produce significant amounts of by-product sulphur as a result of increased abatement of SO_2 emissions from these sources. The most economical form of abatement will generate a sulphuric acid by-product. This acid has the potential to reduce somewhat the cost of abatement to industry; however for this to be the case, new markets must be found. If these new markets cannot be found, then the acid must be neutralized and disposed of since it is impractical and very expensive to store sulphuric acid. Thus, in the absence of a vigorous marketing strategy for sulphur products, the costs of pollution control will be higher and another form of pollution problem can be generated in the form of large volumes of neutralized sulphuric acid.

In testimony before the Sub-committee, a number of witnesses pointed out the useful role of government aid in marketing these by-products. This general suggestion was made by industry spokesmen, union leaders, and provincial politicians. In addition, several research reports have also pointed out the importance of such government support. The Sub-committee concurs with these views on the importance of sulphur by-product marketing.

At the Toronto hearings, the Sub-committee heard testimony from Mr. Murray Gaunt, at the time Liberal Environment Critic in the Ontario Legislature, and Dr. Stuart Warner of INCO Limited, both of whom stressed the need for free access of by-product sulphuric acid to existing markets. In Calgary, the Sub-committee heard testimony from the Sierra Club of Western Canada citing the current stage of development of new uses for sulphur products and the need for further research in this area.

Recommendation 37

The Sub-committee recommends that the Federal Government, in co-operation with the Provincial Governments and the private sector, convene a Task Force on sulphur by-product utilization with the aim of developing a national marketing strategy for sulphur and sulphur products. Such a marketing strategy would involve finding new uses for sulphur products and may include the formation of a marketing board for sulphur and sulphur products.

As the appended Background on Sulphur Markets (Appendix II) points out, the primary use of sulphuric acid is for the production of phosphatic fertilizer. Canada currently has a phosphatic fertilizer industry based on domestic sulphuric acid supplies and imported phosphate. By making use of domestic phosphate deposits, particularly in Cargill Township, Ontario, much of the increased sulphuric acid supply from future pollution abatement can be utilized. Such an expansion of the Canadian fertilizer industry is an attractive proposition because this expansion will use abatement sulphuric acid, and because of the projected excess demand for fertilizer over the next decade. *The Sub-committee views the development of domestic phosphate deposits as one way of providing economic benefits to Canadians and as a means by* *which the burden of SO_2 emissions abatement can be eased.*

A number of witnesses before the Sub-committee recognized the useful role of increased fertilizer production as a complement to SO_2 abatement through sulphuric acid production. Mr. Colin Isaacs, former N.D.P. Environment Critic in the Ontario Legislature, described the development of the Cargill phosphate deposits as a ready-made solution to emissions control at INCO's Sudbury operations. Local 6500 of the United Steelworkers of America suggested that fertilizer production based on abatement acid not be limited by world fertilizer demand. They noted that phosphatic fertilizer is a vital component in attempts by the Third World to increase agricultural production. Increased Canadian foreign aid in the form of fertilizer can thus be linked with Canadian attempts to reduce acid rain-causing pollution.

Recommendation 38

The Sub-committee recommends that Canadian phosphate deposits be developed as a market for the sulphuric acid produced by control of sulphur dioxide in non-ferrous smelters.

APPENDICES

APPENDIX I

Precipitation Chemistry Monitoring Networks in Canada

Network Name	Agency	Geographical Area
1. Canadian Network for Sampling Precipitation (CANSAP)	Department of the Environment, Atmospheric Environment Service	Canada-wide
2. World Meteorological Organization Background Air Pollution Monitoring Network (WMO BAPMoN)	Department of the Environment, Atmospheric Environment Service	Canada-wide
3. Air & Precipitation Monitoring Network (APN)	Department of the Environment, Atmospheric Environment Service	Eastern Canada
4. Canadian Network for Sampling Organics in Precipitation	Department of the Environment, Environmental Conservation Service, Inland Waters Directorate	Canada-wide
5. Acidic Precipitation in Ontario Study (APOS)	Ontario Ministry of the Environment, Air Resources Branch	Ontario
6. Precipitation Quality Monitoring Program (PQMP)	Alberta Department of the Environment	Alberta
7. Precipitation Chemistry in Nova Scotia	Nova Scotia Department of the Environment	Nova Scotia
8. Great Lakes Precipitation Network	Department of the Environment, Environmental Conservation Service, Inland Waters Directorate	Great Lakes Basin
9. Ontario Hydro Air and Precipitation Monitoring Network	Ontario Hydro	Southern Ontario
10. Alberta Oil Sands Environmental Research Program (AOSERP) Precipitation Chemistry Network	Alberta Government	Northern Alberta
11. Nanticoke Environmental Management Program (NEMP)	Ontario Ministry of the Environment, Air Resources Branch	Nanticoke area
12. Limnology Unit Precipitation Sampling Network	Ontario Ministry of the Environment, Water Resources Branch	South-central Ontario

Source: National Research Council Canada, *Acidification in the Canadian Aquatic Environment: Scientific Criteria for Assessing the Effects of Acidic Deposition on Aquatic Ecosystems*, NRCC No. 18475, Ottawa, 1981, p. 300-301.

APPENDIX II

Background on Sulphur Markets

At present there are two major sources of sulphur. Elemental sulphur can be mined using the Frasch technique which is the major method of *voluntary* production. Elemental sulphur can also be produced from sour natural gas. In addition, sulphuric acid and liquid sulphur dioxide can be produced from the abatement of emissions due to the burning of fossil fuels and the smelting of sulphide ores. These last examples represent *involuntary* production of sulphur products.

In 1978 just over one-half of the world's total sulphur production of 52 million tonnes was in the form of involuntary by-products. In Canada almost all sulphur is produced as a by-product. Over 90% of this is elemental sulphur from Alberta sour natural gas while the remainder is sulphuric acid from smelter gases (see Tables 1 and 2).

Almost 90% of all sulphur is eventually consumed as sulphuric acid, yet over 80% of Canada's shipments of sulphur are in elemental form. Acid plants tend to be built near the ultimate user due to the high cost of transporting and storing acid. By-product acid which results from pollution control must compete with acid produced from Alberta's elemental sulphur.

Canada is currently the world's largest exporter of sulphur products, accounting for 35% of foreign trade in sulphur. The United States represents Canada's largest market, although for elemental sulphur our markets are very diversified (see Table 3). Poland is the world's second largest exporter of sulphur with 27% of foreign trade. The largest sulphur markets are the U.S. and U.S.S.R., both of which are consistently net importers despite being the world's largest sulphur producers. These last three countries rely heavily on the mining of sulphur deposits using the Frasch technique for their domestic production.

Increased controls on sulphur dioxide emissions in Canada will significantly increase sulphuric acid production. A 60% reduction in emissions from present levels is estimated to generate an extra 1.8 million tonnes of acid per year. In 1977 Canada produced just under 3.2 million tonnes of sulphuric acid and it is obvious that the size of the domestic market is not sufficient to accommodate this extra acid (see Table 5). The question is, then, whether new markets for this acid can be found.

Major markets for sulphuric acid exist in the mid-western United States. It is estimated that acid from Sudbury can be transported to these markets at costs below $18 U.S. per tonne which would still offer a significant return to acid producers. Based on transportation costs, by-product acid is competitive with acid produced from Frasch sulphur. Sulphur from this latter source has increased significantly in price recently because of the large amount of natural gas required to extract the sulphur. However, by-product acid will also compete in these markets with acid produced from Alberta sulphur, which is much more competitive.

Another potential new market for this sulphuric acid is fertilizer production based on the Cargill phosphate deposits in northern Ontario. These deposits are sufficiently large to support production of up to 900,000 tonnes of phosphate concentrate per year which would require about half of the additional acid output due to pollution controls.

Canada currently has a small fertilizer industry which relies upon imports of phosphate rock. One of the reasons why the Cargill deposits have not been developed is the lack of low-priced sulphuric acid nearby. Increased pollution abatement would provide just such a source.

This phosphatic fertilizer can be produced in a number of forms: normal superphosphate; triple superphosphate; phosphoric acid; as well as ammonium phosphates. When phosphate rock is treated with sulphuric acid, normal superphosphate results. To produce one tonne of normal superphosphate requires 0.64 tonne of phosphate rock and 0.47 tonne of 100% sulphuric acid. If a larger input of sulphuric acid is used, phosphoric acid results which can then be used to produce triple superphosphate. To produce one tonne of phosphoric acid requires 3.1 tonnes of phosphate rock and 2.6 tonnes of pure sulphuric acid.

Sulphur is a raw material used in almost every manufacturing process. Because of its nature as an intermediate rather than final product, the major economic benefits are derived from the consumption of sulphur rather than from its production. As a result, any restrictions on the consumption of the product tend to be self-defeating. This is probably why very few trade restrictions are imposed on sulphur products.

The United States has generally allowed elemental sulphur and sulphuric acid to enter the country free of tariffs. Under the latest Multilateral Trade Negotiations (MTN) the U.S. offered to reduce the tariff on sulphur dioxide from 6% to 4.2%. In Canada only sulphuric acid imports have been subject to tariffs, ranging from the high general rate of 25% to the low preferential rate of 10%. Under the latest MTN, Canada's concessions included the elimination of these duties.

Increased pollution controls will significantly increase the amount of sulphur production. In Canada this will be largely in the form of sulphuric acid. If the United States also significantly reduces sulphur dioxide emissions, then a further increase in by-product sulphur will occur. At present it appears that American by-product sulphur will be largely in the form of gypsum although the option of using abatement techniques which produce sulphuric acid is apparently available. Will sulphur demand keep pace with these increased supplies?

Most sulphur is consumed as sulphuric acid and most of that is used in the production of fertilizer. The Department of Energy, Mines and Resources has predicted tight supplies, and possibly even significant shortages, of fertilizer into the late 1980s. This would imply no slackness in the demand for sulphuric acid; in fact the anticipated fertilizer shortage is blamed on shortages of the acid, despite surpluses of phosphate rock.

Canada's fertilizer industry has always relied on imported phosphate rock. The impetus for the location of this industry in Canada came from the existence of large supplies of sulphur, in particular sulphuric acid. If that is the case, then the size of the fertilizer industry in Canada is limited by the amount of available sulphuric acid. Increases in by-product acid will increase the domestic demand for phosphate rock, which will be supplied from deposits in the U.S. or any newly-developed Canadian deposits.

The role of sulphur marketing in acid rain control is determined by the price of sulphur, in particular sulphuric acid, and the manner in which that price is determined. In 1978 the price of Canadian sulphuric acid was about $58 per tonne while cost of emissions control, reflected in the quantity of acid produced, was about $100 per tonne of sulphuric acid.

The increased supply of sulphuric acid due to increased emissions abatement is bound to drive prices down. This may seem in contradiction to the preceding paragraph but the point is, when firms calculate the cost of producing by-product sulphur, they treat this cost as essentially zero. By-product sulphur is produced not because firms see it as a profitable venture, but because it is the result of required emissions control. Therefore the cost of emissions control represents the cost of producing a cleaner environment, not the cost of producing acid.

In effect, the marketability of by-product sulphur is limited only by transportation costs and possibly also by disposal costs. Elemental sulphur can easily be stored and Alberta stockpiles are currently over 19 million tonnes. Such an option is not available for sulphuric acid because of the storage costs associated with this highly corrosive liquid.

Table 1: Elemental Sulphur Recovered from Crude Petroleum, Natural Gas and Sulphides in Canada

	Quantity Produced (Thousand Tonnes)	Quantity Shipped (Thousand Tonnes)	Value of Shipments (Million $)
1980	7,403	N/A	414.48
1979	6,718	N/A	145.07
1978	5,868	N/A	100.16
1977	6,668	5,207	80.61
1976	6,472	4,030	70.17
1975	6,475	4,079	91.85
1974	6,951	5,033	68.56
1973	7,219	4,168	23.82
1972	6,720	3,299	19.59
1971	4,688	2,857	21.30
1970	4,360	3,219	28.35
1969	3,810	2,698	60.73
1968	3,137	2,342	79.96

"N/A" means data not available.

Note: These figures do not include sulphur from imported crude oil but do include sulphur from nickel refineries. Data for years 1978 to 1980 are preliminary and value data are for production.

Source: Statistics Canada, *Miscellaneous non-metal mines, 1977*, Cat. No. 26-220, Annual, Ottawa, 1979; and Statistics Canada, *Canada's mineral production*, preliminary estimates, Cat. No. 26-202, Ottawa, 1979 and 1980 issues.

Table 2: Sulphur Produced from Smelter Gases in Canada

	Quantity (Thousand Tonnes)	Value (Million $)
1980	903	22.96
1979	605	12.68
1978	673	13.64
1977	736	14.16
1976	705	18.58
1975	695	9.64
1974	663	9.81
1973	687	10.07
1972	559	5.12
1971	509	4.63
1970	581	7.43
1969	556	7.95
1968	548	8.92

Note: 1978 to 1980 figures are preliminary estimates.

Source: Statistics Canada, *Miscellaneous non-metal mines, 1977*, Cat. No. 26-220, Annual, Ottawa, 1979; and Statistics Canada, *Canada's mineral production*, preliminary estimates, Cat. No. 26-202, Ottawa, 1979 and 1980 issues.

Table 3: Sulphur Exports

		Gypsum		Sulphur in Ores		Sulphur, Crude or Refined N.E.S.		Sulphuric Acid, Including Oleum	
		Volume (Tonnes)	Value (Million $)	Volume (Tonnes)	Value (Million $)	Volume (Tonnes)	Value (Million $)	Volume (CWT)	Value (Million $)
1979	Total	5474821	25.90	—	0.28	5154884	206.31	3073799	3.09
	U.S.	5437588	25.70	—	0.28	1239282	26.60	3073773	3.09
1978	Total	5178685	23.03	—	0.06	4984597	163.88	4523140	4.06
	U.S.	5142504	22.84	—	0.06	1181564	20.25	4523131	4.06
1977	Total	4994375	19.14	—	0.21	4291076	122.08	6481464	5.46
	U.S.	4977874	19.07	—	0.21	1181443	18.70	6352968	5.36
1976	Total	3798282	13.10	—	0.15	3720030	109.89	7712352	6.88
	U.S.	3798282	13.10	—	0.15	1011433	18.65	7711850	6.88
1975	Total	3691714	11.38	—	0.17	3284279	113.04	4969261	4.33
	U.S.	3676313	11.34	—	0.17	947770	22.74	4968820	4.32
1974	Total	5212483	13.89	—	0.65	4251530	90.37	5493866	3.85
	U.S.	5157403	13.77	—	0.65	1182101	20.32	5493341	3.85

Source: Statistics Canada, *Merchandise Trade-Exports*, Cat. No. 65-202, Annual, Ottawa, various issues.

Table 4: Sulphur Imports

		Gypsum		Sulphur, Crude or Refined N.E.S.		Sulphuric Acid, Including Oleum	
		Volume (Tonnes)	Value (Million $)	Volume (Tonnes)	Value (Million $)	Volume (CWT)	Value (Million $)
1979	Total	152465	2.96	1699	0.59	3761475	7.30
	U.S.	18154	0.46	1687	0.58	2894495	5.70
1978	Total	70996	1.66	8130	0.98	2375814	4.00
	U.S.	12436	0.34	8005	0.96	1342942	2.42
1977	Total	24042	0.58	14065	0.77	146255	0.32
	U.S.	9760	0.31	14065	0.77	146118	0.32
1976	Total	54770	0.78	15717	1.11	871642	1.89
	U.S.	6982	0.19	15717	1.11	425989	0.84
1975	Total	55339	0.67	14335	0.91	3395560	4.33
	U.S.	16179	0.22	14335	0.91	1737805	2.22
1974	Total	56251	0.51	31389	1.25	2750037	3.02
	U.S.	38463	0.42	31345	1.24	2136023	2.09

Source: Statistics Canada, *Merchandise Trade-Imports*, Cat. No. 65-203, Annual, Ottawa, various issues.

Table 5: Sulphuric Acid Statistics: Production, Foreign Trade, Size of Domestic Market

(in thousand tonnes)

	Production	Exports	Imports	Size of Domestic Market
1977	3141	288	6	2859
1976	2842	350	39	2531
1975	2723	225	153	2651
1974	2821	269	124	2676
1973	2963	122	65	2906
1972	2749	94	64	2719
1971	2661	92	4	2573
1970	2475	130	9	2354
1969	2175	93	55	2137

Note: These figures are for *all* industries producing sulphuric acid. The size of the domestic market is calculated as production plus imports minus exports.

Source: Statistics Canada, *Manufacturers of Industrial Chemicals*, Cat. No. 46-219, Annual, Ottawa, various issues.

Table 6: Manufacturers of Industrial Chemicals: Sulphuric Acid Production

	Quantity (in thousand tonnes)	Value (Million $)
1978	877.09	17.85
1977	1,074.31	23.37

Source: Statistics Canada, *Manufacturers of Industrial Chemicals, 1978*, Cat. No. 46-219, Annual, Ottawa, 1980.

Table 7: Consumption of Elemental Sulphur in Canada, by Industry

(in thousand tonnes)

	1976	1975	1974	1973	1972
Industrial Chemicals	404.98	465.15	417.71	349.87	364.77
Pulp and Paper Mills	258.55	230.09	300.75	272.35	285.73
Misc. Chemicals	17.20	19.33	11.58	28.11	3.90
Smelting and Refining	34.24	63.32	21.18	5.14	1.78
Rubber Products	4.06	3.73	4.07	4.64	4.45
Others	0.39	0.31	0.46	0.44	0.48
Total	**719.42**	**781.93**	**755.75**	**660.55**	**661.11**

Note: Figures may not sum to totals due to rounding.

Source: Statistics Canada, *Miscellaneous non-metal mines*, Cat. No. 26-220, Annual, Ottawa, various issues.

APPENDIX III

Background on the Canadian Non-ferrous Metals Industry

This appendix is designed to provide some information on the current state of the non-ferrous metals industry in Canada and to consider the possible impact of increased SO_2 controls on this sector. In particular, the discussion is concerned with the ability of the industry to absorb the costs of increased pollution control, the ability to pass these costs on to other sectors, and the resultant impact on the economic viability of the industries.

The discussion is in two parts: the copper industry and the nickel industry. The dominance of Canadian producers in world nickel markets exceeds that of Canadian producers in the copper markets. The structure of the two industries also differs so that the final distribution of SO_2 abatement costs among mines, smelters and consumers will differ significantly between the copper and nickel sectors.

The Copper Industry

Canada is currently the largest exporter of copper products and fourth largest copper producer. Despite this relatively strong position, Canadian producers are price takers on the world market. As a result, any increased costs due to SO_2 abatement must be borne by the copper smelters or shifted back to the mines — the degree to which these costs can be passed on to copper consumers is severely limited.

Canadian copper mines are among the most efficient in the world. They can compete effectively against producers in industrialized countries as well as against the low-labour-cost producers of the third world. In fact, the high political risks involved with investment in this latter area have recently reduced some of the potential competition facing Canadian producers. The major source of Canadian mining efficiency is due to the multi-metal nature of domestic ores and the fact that these by-products have all experienced significant price increases in recent years.

The imposition of SO_2 controls on copper smelters will reduce the price which the smelters will be willing to pay for the copper concentrate. This reduced demand for copper concentrate represents the means by which these increased costs can be shifted backwards to copper mines. This will reduce the viability of some mines; reduce employment, output and investment in certain mines and; in general result in a lower value for Canada's mineral resources. While a number of scenarios are conceivable, the following table presents one calculation of such effects on the mining sector.

While such a backward shifting of costs to the mining sector is to be expected, this by no means implies that the Canadian smelters will not bear any of the burden of SO_2 control costs. Canadian smelters must compete with foreign, mainly Japanese, smelters for copper concentrate. The Japanese smelters are subsidized by high producer prices and tariff protection which give them an advantage in bidding for copper concentrate. This is in large part responsible for the export of concentrate from British Columbia to Japan. Despite the transportation cost involved in such exports, a B.C. smelter could not compete with Japanese smelters. Thus the ability of Canadian smelters to pass back SO_2 control costs to mines is limited by foreign demand for Canadian copper concentrate.

The above general observations must be tempered when considering individual copper smelters. The Horne Smelter at Rouyn-Noranda, owned by Noranda Mines Ltd., is currently the largest single source of SO_2 emissions in Quebec, and is

Table 1: Effects of Various Levels of Sulphur Dioxide Control on Canadian Shield Base-Metal Mines

	Number of Economic Deposits	Development Phase Investment ($ Million)	Net Present Value at 8 Per cent ($ Million)	Rate of Return (Per Cent)
Existing Conditions	40	1,817	1,899	17.2
29 Per Cent Control	40	1,817	1,751	16.6
61 Per Cent Control	39	1,802	1,625	16.2
90 Per Cent Control	39	1,802	1,542	15.8

Source: Brian E. Felske and Associates, *Sulphur Dioxide Regulation and the Canadian Non-Ferrous Metals Industry*, Economic Council of Canada, Technical Report No. 3, Ottawa, 1981.

therefore a natural target for controls. Any significant amount of abatement at this facility will require a large-scale rebuilding of the smelter.

At present the Horne smelter represents an economically marginal operation. The plant is currently a custom-smelting operation due to the exhaustion of the Horne mine. Much of the feedstock from other Quebec mines will also be significantly reduced due to the exhaustion of these mines in the near future. Moreover, the concentrate from Texasgulf operations will be reduced as the new smelter at Timmins, Ontario comes into operation.

The present economic conditions in the copper industry suggest that the profitability involved with the construction of any new copper smelter is dubious at best. The capital costs of new smelter operations have increased significantly over the past two decades. To recover only these capital costs requires a smelter charge of 35¢ per pound of copper, compared to the current smelter charge of 12¢ - 25¢ per lb. Therefore at current prices, new smelters will find it difficult to compete with existing ones.

Sulphur dioxide abatement at the Hudson Bay Mining and Smelting operation at Flin Flon, Manitoba will also require a significant rebuilding of the entire smelting facility. High capital costs will also be a factor in this case. However, unlike the Noranda facility discussed above, the Flin Flon smelter obtains 64% of its raw material from its own mines. In this respect, some of the added costs of SO_2 abatement can be internalized within the entire HBMS operations. With respect to the custom smelting portion of the plant's operations, it is not clear to what extent these costs can be passed on to other mines.

Sulphur dioxide control is expected to be less expensive at the HBMS facility than at the Noranda smelter. In addition, the HBMS smelter is not in the same precarious position the Noranda operation finds itself in. However, this does not imply that the Flin Flon smelter will not experience difficulties in the face of SO_2 control orders.

In this report it was made clear that the Sub-committee does not intend to impose severe economic harm on corporations or communities in its quest for a solution to the acid rain problem. This discussion of the copper industry in Canada points out the need for governments to consider the economic impact of SO_2 control orders on local communities. The need for such consideration is obvious in the case of the smelter at Rouyn-Noranda. To a lesser extent, SO_2 controls may also generate difficulties with respect to the smelters at Flin Flon, Manitoba and Murdochville, Quebec. As a result, it is necessary for governments to achieve their goal of SO_2 abatement in a manner which minimizes the economic and social costs associated with such a policy.

The Nickel Industry

Canada is currently the world's largest producer and exporter of nickel. In 1980, Canada accounted for 33% of non-communist production as opposed to 92% of world production in 1950. At one point, in 1978, Canadian nickel production fell below that of the U.S.S.R. Although Canadian dominance of world supply has been significantly diminished, it is still large enough for Canadian producers to have some control over prices.

Canadian ores are generally of exceptionally high grade. In addition, Canadian ores require small amounts of energy for smelting due to the sulpher content; enjoy low energy prices; and benefit from the existence of valuable by-product metals in the ore. As a result, Canadian nickel operations are the lowest-cost producers in the world.

Canadian nickel producers compete with foreign nickel largely extracted from laterite ores. Although these foreign operations often benefit significantly from government subsidies, they also represent very high-cost operations due to the large energy requirements associated with lateritic ores. In addition, these foreign operations often are located in areas which require large scale infrastructure investments. Overall, then, these foreign sources do not represent any significant threat to Canada's nickel producers.

The nickel industry is now recovering from the 1975-79 slump which saw producer inventories significantly increased and prices fall as low as $1.65 U.S. per pound. The demand for nickel has rebounded significantly from the depressed state of the late 70s. This is witnessed by higher prices and reduced inventories. A number of factors suggest that this strong demand for nickel will continue well into the 1980s which could lead to shortages later in the decade. The factors indicating a strong demand for nickel include: an upturn in general economic activity leading to increased capital expenditures which accounts for 70% of nickel consumption; the possible development of electric cars which would use large amounts of nickel in the battery; increased use of pollution control devices which are large users of nickel; and increased aircraft production (both civilian and military) which again constitutes an intensive use of nickel. This strong demand for nickel will be largely for Class I product of which Canadian producers supply 50 per cent of world demand.

On the basis of this anticipated strong demand for nickel, the cost competitiveness of Canadian producers, their dominant position in the market and relative financial health, the imposition of SO_2 controls does not appear to place any undue burden on the Canadian industry. It should be pointed out

Table 2: Financial Performance of Select Polluters

	Net Income After Taxes	Total Assets	Shareholders' Equity	Return on Assets	Return on Equity
	(in million dollars)			(%)	
INCO*					
1980	219	4632	2162	4.73	10.13
1979	142	4335	2006	3.28	7.08
1978	78	4146	1918	1.88	4.07
1977	100	4076	1915	2.45	5.22
1976	197	3628	1562	5.43	12.61
1975	187	3026	1484	6.18	12.60
Falconbridge					
1980	109	1159	506	9.40	21.54
1979	111	1069	496	10.38	22.38
1978	6	867	384	0.69	1.56
1977	-29	888	383	—	—
1976	15	736	321	2.04	4.67
1975	3	763	310	0.39	0.97
HBMS					
1980	63	858	337	7.34	18.69
1979	31	735	286	4.22	10.84
1978	5	670	260	0.75	1.92
1977	4	619	255	0.65	1.57
1976	3	474	204	0.63	1.47
1975	15	518	217	2.90	6.91
Noranda					
1980	408	3938	2001	10.36	20.39
1979	410	3320	1463	12.35	28.02
1978	134	2375	884	5.64	15.16
1977	67	2153	754	3.11	8.89
1976	47	2093	715	2.25	6.57
1975	51	1980	697	2.58	7.32
Algoma Steel					
1980	109	1422	878	7.67	12.41
1979	112	1224	719	9.15	15.58
1978	70	1053	628	6.65	11.15
1977	38	975	560	3.90	6.79
1976	24	928	451	2.59	5.32
1975	37	851	385	4.35	9.61
Imperial Oil					
1980	601	6244	3789	9.63	15.86
1979	471	4668	2440	10.09	19.30
1978	314	3893	2086	8.07	15.05
1977	289	3401	1910	8.50	15.13
1976	264	3139	1736	8.41	15.21
1975	250	2950	1578	8.47	15.84
Suncor**					
1980	306	1731	1102	17.68	27.77
1979	170	1256	798	13.54	21.30
1978	19	380	256	5.00	7.42
1977	11	351	237	3.13	4.64
1976	9	332	224	2.71	4.02
1975	-4	333	212	—	—

* Inco data are in U.S. dollars.

** For the years 1975 to 1978, the data are for Great Canadian Oil Sands Ltd.

Source: The Financial Post Corporation Service.

that some concern has been expressed with respect to their ability to take advantage of this increased demand in the face of production constraints due to SO_2 control.

The integrated nature of most Canadian nickel operations indicates an ability to internalize these control costs over a wide range of operations. The low cost of production and the still dominant position of Canadian producers suggest that domestic nickel producers — in particular INCO — are to some extent price leaders. Thus, unlike Canadian copper producers, domestic nickel producers possess the ability to pass some of their costs of SO_2 control forward to consumers.

APPENDIX IV

List of Witnesses

Witnesses Who Appeared at Ottawa Hearings

On Thursday, August 28, 1980:

From the Department of the Environment:

Mr. R.M. Robinson, Assistant Deputy Minister, Environmental Protection Service

Mr. J.P. Bruce, Assistant Deputy Minister, Environmental Management Service

Mr. Floyd Elder, Aquatic Ecosystems

Mr. Peter Rennie, Canadian Forestry Service

Mr. Alex Manson, Control Systems, Air Pollution Programs Branch, Environmental Protection Service

Dr. Hans Martin, Co-ordinator, Federal LRTAP Programme, Atmospheric Environment Service

On Wednesday, September 10, 1980:

Dr. D.G. Kelley, Director, Air Pollution Programs Branch, Department of the Environment

Mr. Eric Lykke, Director General, Information and Organization, Ministry of Environment, Oslo, Norway

Dr. Hans Martin, Co-ordinator, Federal LRTAP Programme, Atmospheric Environment Service, Department of the Environment

Dr. S.S. Singh, Chemistry and Biology Research Institute, Agriculture Canada

Dr. Robert G. Skinner, Head of Environmental Group, Department of Energy, Mines and Resources

Mr. Martin Rivers, Director General, Air Pollution Control Directorate, Department of the Environment

Mr. R. Hickman, Acting Director General, Environmental Health Directorate, Department of Health and Welfare

Dr. Pat Schmut, Chief, Chemical Hazards, Department of Fisheries and Oceans

On Tuesday, October 21, 1980:

From the United Nations Economic Commission for Europe:

Mr. J. Stanovnik, Executive Secretary

On Thursday, April 9, 1981:

From the Petroleum Association for Conservation of the Canadian Environment:

Mr. H.H. Clare, Secretary-Treasurer

Mr. A.L. Scott, Chairman, Air Quality Committee

Witnesses Who Appeared at Regional Hearings Calgary, Alberta

On Monday, February 16, 1981:

From Calgary Power Limited:

Mr. Richard W. Way, Executive Assistant

Mr. John Railton, Manager, Environmental Planning

From Alberta Power Limited:

Mr. J.R. Frey, Manager, Planning

Mr. Douglas Leahy, Consultant

From the Canadian Petroleum Association:

Mr. Ian Smyth, Executive Director

Dr. Martin Winning, Manager, Environmental Affairs, Shell Canada Resources Limited

Mr. Al Smandych, Manager, Environmental Conservation Department, Hudson's Bay Oil and Gas Limited

Mr. Ron Findlay, Manager, Environmental Affairs, Amoco Canada Petroleum Company Ltd.

Ms. Sheila Cameron, Environmental Advisor, Chevron Standard Limited

From the Oil Sands Environmental Study Group:

Mr. John R. Clements, Chairman, OSESG Committee on Effects of Air Pollutants on the Environment

From Esso Resources Canada Limited:

Mr. E.R. Caldwell, Head of the Regulatory Compliance Section, Production Department

Mr. Bill Ross, Environmental Co-ordinator, Heavy Oil Department

Mr. Doug Howell, Engineering Specialist, Process Engineer

Mr. Herb Jacobson, Environmental Advisor, Production Department

From Syncrude Canada Limited:

Mr. George Lesko, Director, Environmental Office

From the Sierra Club of Western Canada:

Mrs. Pat Kariel, Representative

Mr. Doug Caldwell, Independent Businessman

From Saskatchewan Environment:

Mr. L.J. Lechner, Director, Air Pollution Control Branch

From the Public Advisory Committee to the Environment Council of Alberta:

Dr. Martha Kostuch, Chairman, Co-ordinating Committee

From the Alberta Fish and Game Association:

Mr. A. Ferguson

From the Canadian Nature Federation:

Mr. Richard Pratt, Conservation Director

From the University of British Columbia:

Mr. David P. Bernard, Student, Institute of Resource Ecology

From the South Central Tribal Council:

Mr. Gérald Étienne, Chairman

Mr. Dan Barz, Planner

From the Union of British Columbia Indian Chiefs:

Mrs. Lillian Basil, Co-ordinator of Energy and Resources Portfolio

Mr. Jim Brisebois, Consultant, Environmental Advisor

Dr. Michael Church, Consultant

Mr. Stephen Basil, Field Worker on Hat Creek project

From the Alberta Society of Professional Biologists:

Mr. Don L. Dabbs, President

Dr. S.B. Smith, Member of the Board of Directors

Mr. R.E. Wolf, Geologist

Halifax, Nova Scotia

On Monday, April 13, 1981:

From the Nova Scotia Department of the Environment:

Mr. Robert Bailey, Director, Policy Planning and Co-ordination

Mr. A.L. Carroll, Chief, Operations

Mr. John Underwood, Environmental Analyst, Environmental Assessment Division

From the Institute for Resource and Environmental Studies, Dalhousie University:

Dr. Susan Guppy, Program Co-ordinator

From the Department of Environment, Province of Newfoundland:

The Honourable Hal Andrews, Minister of the Environment

Mr. W.A. Kinsman, Deputy Minister of Environment

Mr. D.S. Jeans, Assistant Deputy Minister of Environment

Mr. Brian Power, Director of Industrial Environmental Engineering

From the Canadian Coalition on Acid Rain:

Mr. Michael Perley, Executive Co-ordinator

From the National Council of Women of Canada:

Mrs. Maryon Grant, Vice-President

Dr. Constance MacFarlane, Environment Chairman

Miss Mary Wall, Provincial Chairman

From the Department of the Environment, Province of New Brunswick:

Dr. David L. Besner, Director, Environmental Services Branch

Mr. James Knight, Chief, Air Quality Section, Pollution Control Branch

Mr. William C. Ayer, Environmental Services Branch

From the Department of Community Affairs, Prince Edward Island:

Mr. Stanley Vass, Environmental Policy Advisor to the Minister

From the Halifax West High School:

Mr. Michael Atwell, Student

From Oromocto High School, New Brunswick:

Miss Lillis Barnett, Student

Mr. Harold Picken, Student

Mr. Bill Magee, Student

Mr. Doug MacDonald, Student

Mr. Casey Yavis, Student

From the Canadian Nature Federation:

Mr. Hal Mills, Vice-President

From the Natural History Society of Prince Edward Island:

Mr. Earle Hickey

From the Ecology Action Centre:

Ms. Susan Holtz, Research Co-ordinator

From the Nova Scotia Salmon Association:

Mr. J.C. Gourlay, Co-ordinator, River Committees

From the Nova Scotia Wildlife Federation:

Mr. David L. Ayles, President

Mr. Joseph Y. Hickman, Past President

From Dalhousie University:

Professor Don Munton, Department of Political Science

From the Halifax Wildlife Association:

Mr. David L. Ayles, Director

From the Nova Scotia New Democratic Party:

Mr. Chris Parke, Director of Research

From the Socialist Environmental Protection and Occupational Health Group:

Mr. David Orton, President

Montreal, Quebec

On Monday, January 26, 1981 and on Tuesday, January 27, 1981:

From the Montreal Urban Community:

Mr. Walter Brabant, Assistant Director, Air Purification Division

Mr. Guy Ouellet, Forest Engineer

From Noranda Mines Limited:

Dr. F. Frantisak, Director of Environment Services

Mr. Peter Fowler, General Manager, Horne Division

From Domtar Incorporated:

Mr. Ronald McLean, Head, Environment Sciences Group, Research Center

Dr. G.H. Tomlinson, Senior Consultant

From the Grand Council of the Crees (of Quebec):

Mr. Alan Penn, Consultant

From STOP:

Mr. Bruce Walker, Research Co-ordinator

Mr. Charles Mallory, Director

From the Association des biologistes du Québec:

Mr. André Ahern, Vice-Chairman

From the Société pour vaincre la Pollution:

Mr. Daniel Green, Vice-Chairman

Toronto, Ontario

On Thursday, October 2, 1980 and on Friday, October 3, 1980:

From the Ontario Ministry of the Environment

Mr. J. Walter Giles, Senior Assistant Deputy Minister

Mr. Colin Isaacs, M.P.P. (Ontario)

Mr. Murray Gaunt, M.P.P. (Ontario)

From the Regional Municipality of Sudbury:

Mr. George Lund, Chairman

From INCO Limited:

Dr. J.S. Warner, Vice-President, Environmental and Occupational Health

From the University of Guelph, Department of Political Studies:

Mr. O.P. Dwivedi, Professor and Chairman

Mr. Thomas Babcock

Ms. Peggy Schenk

From the Union of Ontario Indians:

Mr. Allan Roy, Director of Environment

From the University of Toronto, Faculty of Forestry:

Mr. Paul L. Aird, Associate Professor

From Ontario Hydro:

Mr. J.E. Wilson, Manager of Public Hearings

Dr. Ray Effer, Manager of Environmental Studies and Assessments, Design and Development Division

From the United Steelworkers of America, Local 6500, Research Committee:

Mr. Jim Giroux

Mr. Dick Kerr

Experts Who Contributed to International Briefings

London, England

On April 24-28, 1981:

From the Department of Environment:

Dr. L. Read, Head, Air and Noise Division

From the Central Electricity Research Laboratories:

Dr. G. Howells, Director of Research

From the Botany Department, Imperial College, London University:

Professor J.N.B. Bell

Professor A.J. Rutter

Professor M.R. Ashmore

Stockholm, Sweden

On April 29 to May 1, 1981:

Members of Swedish Parliament:

Mr. Einar Larsson, President of Agriculture Committee

Mrs. Grethe Lundblad, Member of Agriculture Committee

From the National Swedish Environmental Protection Board:

Mr. William Dickson, Chief Staff Engineer

Mr. Lars Lindau, Head of Division, Technical Department

Mr. Jan Nilsson, Head of Section, Swedish Research Programme

Mr. Goran Persson, Director, Research Department

From the Ministry of Agriculture:

Mr. Olof Nilsson, Under-Secretary of State for the Department of Agriculture

Mr. Bo Assarsson, Head of Section

Washington, D.C.

On September 17-18, 1980:

From the United States Senate:

Senator George J. Mitchell

Senator Patrick J. Leahy

Senator Donald W. Riegle, Jr.

Senator David F. Durenberger

Senator Jennings Randolph

Senator William S. Cohen

Senator Daniel Patrick Moynihan

Senator Paul E. Tsongas

Senator Max Baucus

From the United States House of Representatives:

Representative Richard L. Ottinger

Representative John D. Dingell

Representative Don Fuqua

Representative Jerome A. Ambro

Representative Henry A. Waxman

Representative Bob Eckhardt

Mr. Douglas Costle, Administrator, Environmental Protection Agency

Mr. Robert Harris, Council on Environmental Quality

Mr. Jerry L. Pfeffer, Assistant Administrator for Utility Systems, Department of Energy

Mr. Gregory Wetstone, Environmental Law Institute

Ms. Frances Dubrowski, Natural Resources Defence Council Inc.

Mr. Robert J. Rauch, Alliance to Save Energy

Mr. Michael Tinkleman, Washington Representative, Energy Analysis and Environment Division, Electric Power Research Institute

Smelting Operations Visited by the Sub-committee

Noranda, Québec

Thursday, July 16, 1981

MINES NORANDA LIMITÉE
Mr. Peter Fowler, General Manager, Horne Division

Belledune, New Brunswick

Tuesday, April 14, 1981

BRUNSWICK MINING AND SMELTING CORP. LTD.
Mr. Alan Young, Vice-President

Sudbury, Ontario

Tuesday, February 3, 1981

INCO LTD.
Dr. Walter Curlook, President and Chief Executive Officer, INCO Metals Company

FALCONBRIDGE NICKEL MINES LTD.
Mr. Gord Slade, President

Oil Sands Mining and Extraction Operations Visited by the Sub-committee

Fort McMurray, Alberta

Tuesday, February 17, 1981

SUNCOR INCORPORATED

Mr. W.L. Olivier, Vice-President, Administration

SYNCRUDE LTD.

Mr. J.R. Lynn, Senior Vice-President, Operations

Individuals and Organizations Who Submitted Briefs and Letters to the Sub-committee, But Who Did Not Appear as Witnesses

The Algoma Steel Corporation Ltd.
  Sault Ste. Marie, Ontario

Associated-Pullman Kellogg Ltd.
  Toronto, Ontario

The Canadian Bar Association
  Ottawa, Ontario

The Canadian Environmental Law Research Foundation
  Toronto, Ontario

Mr. George Child
  Scotsburn, Nova Scotia

Mr. Merrit Clifton
  Brigham, Quebec

Mr. Wayne Conrad
  Brooklin, Ontario

Eastern Shore Wildlife Association
  Halifax, Nova Scotia

Falconbridge Nickel Mines Limited
  Canadian Nickel Division
  Sudbury, Ontario

The Federation of Ontario Naturalists
  Toronto, Ontario

Mrs. Anne Fergusson
  Alexandria, Ontario

Fort Saskatchewan Engineering Services Ltd.
  Fort Saskatchewan, Alberta

Mr. John Franklin
  Baie d'Urfé, Quebec

Friends of the Earth
  Ottawa, Ontario

Grand Council Treaty No. 3
  Kenora and Fort Frances, Ontario

The Haliburton County Anti-Pollution Committee
  Minden, Ontario

Halifax Field Naturalists
Halifax, Nova Scotia

Dr. Harold Harvey
Professor of Zoology
University of Toronto

Hudson Bay Mining and Smelting Co. Ltd.
Flin Flon, Manitoba

The International Atlantic Salmon Foundation
St. Andrews, New Brunswick

The New Brunswick Federation of Agriculture
Fredericton, New Brunswick

The Nova Scotia Power Corporation
Halifax, Nova Scotia

The Nova Scotia Resources Council
Halifax, Nova Scotia

Mr. and Mrs. Sarandi Pefanis
Alexandria, Ontario

Pollution Probe
Toronto, Ontario

The Quetico Foundation
Toronto, Ontario

Jessie Reiffenstein
Oakville, Ontario

Mr. Edson C. Setliff
West Vancouver, B.C.

Dr. Harvey B. Silverstein
Dalhousie University
Halifax, Nova Scotia

The Sudbury and District Chamber of Commerce
Sudbury, Ontario

The Waterloo Public Interest Research Group
Waterloo, Ontario

APPENDIX V
Glossary

Acid	A concentration of hydrogen ions (H+) in solution. Acidity is expressed on a numerical pH scale. An acidic solution has a pH less than 7.0.
Acid rain	Precipitation, including rain, snow, sleet, hail, etc. with a pH less than 5.6. Acid rain consists of "wet deposition" and "dry deposition".
Annual capital cost	The annualized value of capital expenditures, calculated over the lifetime of the capital equipment. This calculation takes into account factors such as interest rates and depreciation.
Base	The opposite of acid; depends on the concentration of hydroxyl ions (OH^-) in solution. A basic or alkaline solution has a pH greater than 7.0.
Buffer	A chemical which, in solution, will resist changes in pH or, if added to a solution, will change the pH of that solution. In nature, limestone (calcium carbonate) will act as a buffer against acid rain to maintain or raise the pH of a waterbody.
Capital cost allowance	A reduction in tax liabilities due to expenditures on capital goods. To the extent that these allowances exceed the estimated costs such as depreciation, interest costs, etc., the allowances are "accelerated".
Cost shifting	The process whereby a firm passes on some of its increased costs. Forward shifting involves passing on costs to consumers through reduced supply. Backward shifting involves passing on costs to suppliers through reduced demand for inputs.
Dry deposition	A process whereby particles such as fly ash, sulphates and nitrates, and gases such as sulphur dioxide and nitric oxide are deposited on, or adsorbed onto, surfaces. The dry particles or gases can be converted into acids after deposition when they contact water.
External cost	A cost generated by the production activity of one firm which is imposed upon a third party having no direct dealings with the source of this cost. For example, the smelting of non-ferrous metals may impose added costs of operation on forest industries via decreased yields due to acid rain.
Leaching	A natural process by which water dissolves minerals out of rocks. The leaching of heavy metals, such as mercury, into water supplies is believed to be a serious consequence of acid rain.
Limestone	A sedimentary rock consisting chiefly of calcium carbonate. Limestone is an effective buffer against acid rain.
Marketing Board	An agency assigned the task of marketing some product or line of products. In some cases the board may be empowered to control the supply of the products in question.
Matte	The product of a reverberatory furnace in a smelter; matte is metal with some contained sulphur and must be further refined to obtain the pure metal.
Metallurgy	The process of extracting metals from their ores.

National Ambient Air Quality Objectives	Prescribed by the Federal Government under the **Clean Air Act** to reflect regional air quality goals in three ranges — 'tolerable', 'acceptable' and 'desirable'. They are not source-specific but are geographical area-specific. They are applicable to specific air contaminants. They are enforceable by the provinces once adopted by them as part of their environmental laws in virtue of a federal-provincial agreement under the federal **Clean Air Act.**
National Emission Guidelines	Enacted by the Federal Government under the **Clean Air Act** to indicate the quantity and concentration beyond which an air contaminant should not be emitted into the atmosphere by a stationary or other type of source. These guidelines are source-specific and are only enforceable by a province when they are adopted under provincial environmental law.
National Emission Standards	Enacted by the Federal Government under the **Clean Air Act** to establish maximum rates of air contaminants that may be emitted by a stationary source if such an emission is a threat to human health or would cause Canada to violate an international obligation it has undertaken in reference to air pollution abatement. Such Standards do not require provincial adoption to be enforceable; in other words, they may be directly enforced by the Federal Government.
pH	A numerical expression of the concentration of hydrogen ions in solution. The units are expressed as the negative logarithm of the hydrogen ion concentration: pH 0 to 7 is acidic, pH 7.0 is neutral and pH 7 to 14 is basic or alkaline.
Pollution rights	A system of marketable permits allowing the bearer to emit a specified level of pollutants. Under this rights system, the government controls the total level of emissions, but not the distribution of these emissions among firms.
Pyrrhotite	An iron sulphide which is associated with nickel. The nickel ores in Sudbury, for example, are pyrrhotite. This ore is also known as sulphide ore.
Reverberatory furnace	A long, flat furnace used in smelting copper concentrates to produce matte.
Sedimentary rocks	Secondary rocks formed from material which is derived from other rocks and which is laid down under water. Examples are limestone, shale and sandstone.
Smelter	A plant in which metals are recovered from the sulphides, oxides, etc. of ore minerals. Smelting is a reduction process carried out in the dry state at incandescent temperatures.
Specific Emission Standards	Where a National Ambient Air Quality Objective has been adopted, the Federal Government may adopt and enforce Specific Emission Standards under the **Clean Air Act** to establish maximum rates of air contaminants emitted by a stationary source under federal jurisdiction.
Sulphide	A compound of sulphur with another chemical element.
Ton	Also known as a short ton, it contains 2,000 pounds. One ton equals 0.9072 tonne.
Tonne	A metric ton, or tonne, contains 1,000 kilograms, or 2,204.623 pounds. One tonne equals 1.1023 tons.
Wet deposition	A process of precipitation whereby acidic chemicals, including dilute sulphuric and nitric acids and sulphates, are deposited in rain, snow, etc.

APPENDIX VI

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(b) Work Group 1 — Impact Assessment
(c) Work Group 2 — Atmospheric Modelling
(d) Work Group 3B— Emissions, Costs and Engineering Assessment

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Photo credits: Agriculture Canada; Mark Bell; John Cahill; Canadian Government Office of Tourism; Canadian Unity Information Office; The Citizen; Daye Atlantic Salmon Corporation; Environment Canada; Fisheries and Oceans Canada; Four by Five Photography Inc.; Friends of the Boundary Waters Wilderness, Inc.; Heritage Canada; George Hunter; The Image Bank of Canada; Industry, Trade and Commerce; Miller Services Ltd.; NFB Phototheque; Ontario Ministry of the Environment; Quebec Ministry of the Environment; Scholastic Inc.; Waterloo Public Interest Research Group; Dr. Leslie Whitby.